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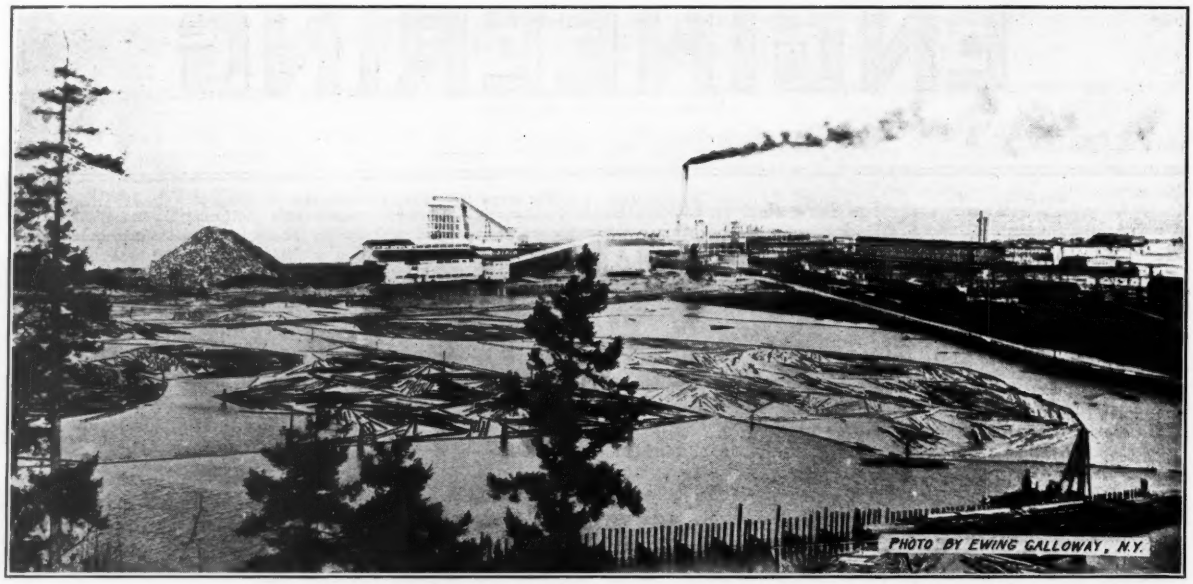
The Tooner

FAR BEYOND "where the west begins" in a narrow gorge, filled with primeval forests and hemmed in by majestic snow-capped peaks, runs the tooner. A hybrid —the only child of a model T flivver and a wayward boxcar, she has the evils of both, the virtues of neither. Born on a road where necessity is of greater importance than comfort, she knows neither the luxury of rubber tires nor the sweet indulgence in periods of demurrage. Yet in time of need she responds nobly and has saved many a Seattle city official's life in getting him home to dinner on time; for the tooner is part of the municipal system supplying power to the city of Seattle and when committeemen and other city officials have occasion to inspect the new dam on the Skagit River which the city is constructing, the tooner serves to take them over the 14 odd miles that separate the base town of Rockport and the dam. In the afternoon it meets the 4:30 train back to Seattle. So the officials think a great deal of her and have affectionately named her the Tooner, with due respects to Fountain Fox.

The tooner is a remarkable vehicle on a remarkable road. This road was constructed by the City of Seattle for the purpose of conveying men and material to their several hydro-electric sites on the Skagit River and is one of the few railroads in the world boasting of steam, electric, gasoline and hand propelled vehicles all on the same tracks.

At the present time the Tooner is kept busy because of the great activity resulting from the construction of the Diablo Canyon Dam. This dam, pictures of which are shown on page 1125, when completed will be one of the highest in the world.



Power Plant Practice in the Pacific Northwest

ABUNDANCE OF WATER POWER AND CHEAP REFUSE FUEL MAKE POWER PROBLEMS IN THE NORTHWEST DIFFERENT FROM THOSE IN THE EAST.

WITH UNUSUALLY large hydroelectric power resources and with an abundance of cheap fuel in the form of wood waste from the lumber industry available, it is natural that power plant practice in the Pacific Northwest should differ considerably from that in other sections of the country where fuel is costly and water power scarce. Power plant practice, like everything else, is based upon economic principles and it is to be expected that where underlying facts differ, the resulting practice will be different.

Certainly, in a territory where most of the fuel is refuse and where large quantities of this are available, there is not the necessity for maintaining high combustion efficiency; consequently, the power plants in such a territory will not have the refinements and highly efficient equipment found in plants using high-priced fuel.

This is precisely the case in the Pacific Northwest. For many years, due to the extent of the lumber industry, there has been more wood refuse available than was necessary and the problem was largely one of disposing of it in the cheapest manner possible. Even today, as one travels through the country, the refuse incinerators at each lumber plant is a familiar sight and one which labels the lumber plant from great distances. These incinerators are tall cylindrical brick furnaces, with a dome-shaped wire netting over the top to prevent sparks and embers from being carried out.

During recent years, due to a greater demand for power and also perhaps to a keener appreciation of the necessity for conservation of resources, most of the refuse has been "hogged" and used for steam raising purposes, not only at the lumber plants but also at plants of other industries nearby.

Until quite recently, most plants using this refuse fuel were equipped with only the essential elements of a steam generating plant. Few instruments were installed and no check was maintained on the efficiency of combustion.

Many Modern Plants Under Construction

With the steady growth of the Pacific Northwest and its consequent industrial expansion, a change in the character of the power plants is beginning to take place. The new plants are built with an eye toward efficiency and are designed along lines dictated by eastern practice. A number of such plants are already in operation in various parts of Washington and British Columbia and others are under construction. The largest of these is probably the new steam plant of the British Columbia Electric Co., at Vancouver, B. C., which will cost in excess of two and a half million dollars.

Greatest activity in the power in the Pacific Northwest is in the coast cities of Washington. In these cities, many new industries are being developed and their need for power is reflected in the construction of new power plants. There is also considerable activity in the southwest portion of Idaho, and in and around Butte, the mining industry is lending impetus to power development.

Pulp and Paper Industry Active

Among the new industries, the pulp and paper industry is undergoing great expansion and a number of new plants are under construction. In the vicinity of Seattle, the Zellerbach paper interests, who have recently become associated with the Crown Willamette Paper interests have recently extended their plant, the

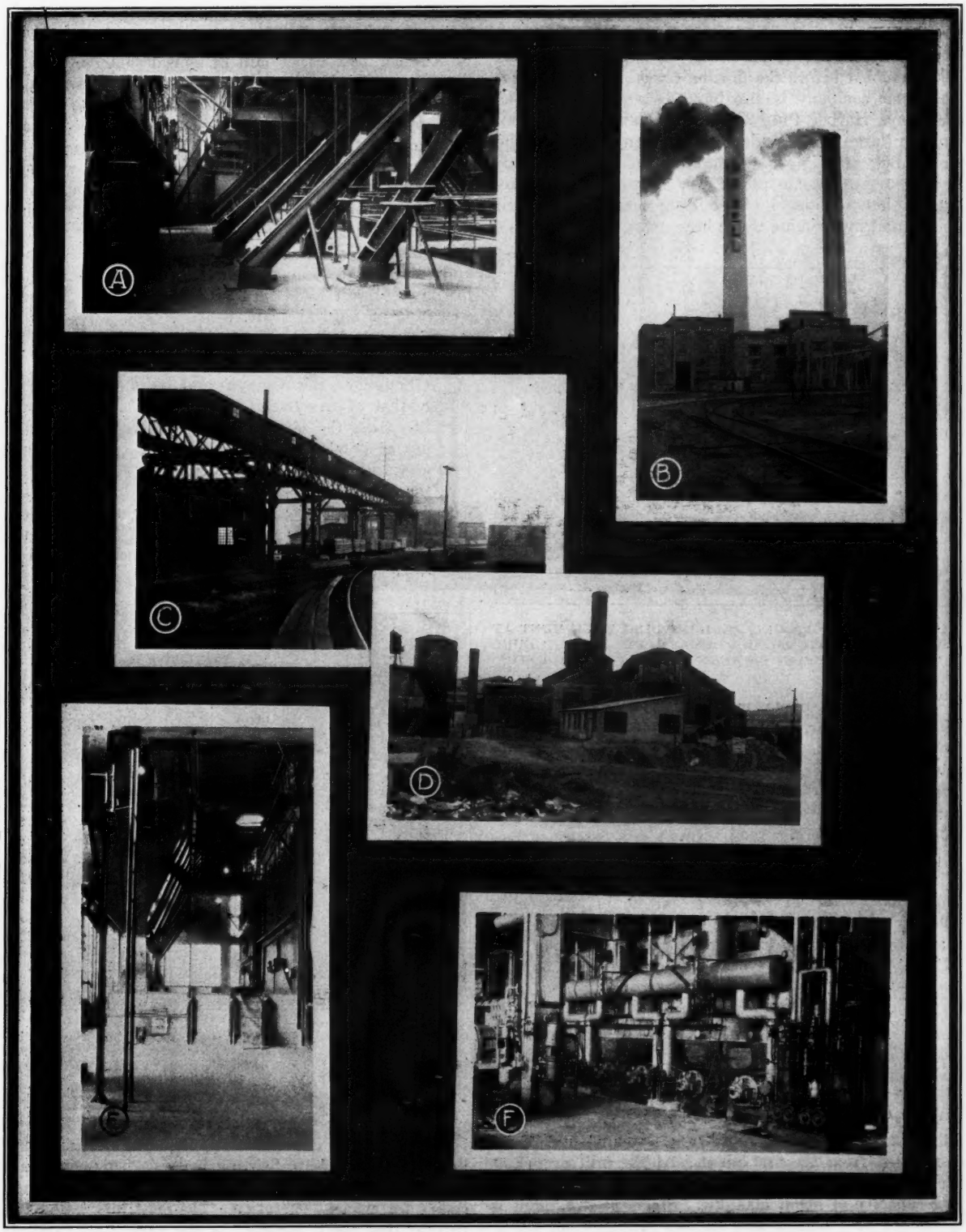


FIG. 1. VIEWS OF VARIOUS POWER PLANTS IN THE PACIFIC NORTHWEST

A. In the boiler room of the Longbell Lumber Co. plant at Longview. B. An exterior view of the Longbell power plant. This station has an installed generator capacity of 18,000 kw. C. A typical view in the lumber plants of the Northwest. This is the hogged fuel conveyor to the power plant of the St. Paul and Tacoma Lumber Co., at Tacoma. D. The L Street Station of the Portland Electric Co. at Portland, Oregon. This plant also burns hogged fuel. E. In the boiler room at the Washington Pulp and Paper Co., Port Angeles, Wash. F. Boiler installation at the Seattle Ice Cream Plant of the Western Dairy Products Co.

Washington Pulp and Paper Co., at Port Angeles and are putting in a new plant called the National Paper Products Co. at Port Townsend, Wash. The Port Townsend plant is of particular interest because it is being doubled before the first half was even completed. This same company is also building a plant known as the Grays Harbor Pulp Co. at Hoquiam, Washington. Another large plant under construction is that of the Union Bag and Paper Corporation, at Tacoma. This is only to be a steam plant, electric power being purchased, but will have two 807-hp. hogged fuel fired boilers and five 456-hp. waste heat units.

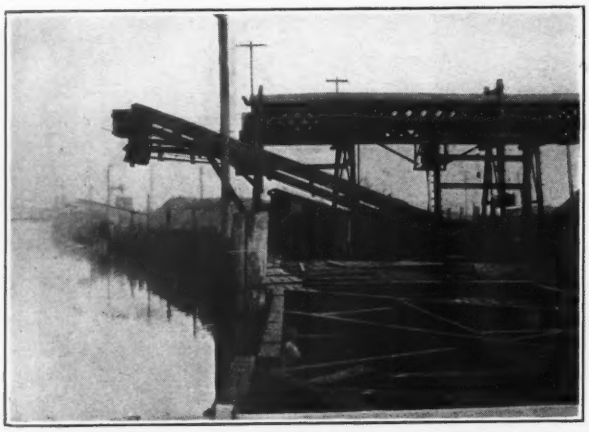


FIG. 2. TYPICAL HOGGED FUEL LOADING EQUIPMENT AT THE ST. PAUL AND TACOMA LUMBER CO. HOGGED FUEL STORAGE PILE CAN BE SEEN IN THE BACKGROUND

Most of the paper mills use hydroelectric power either from their own plants or purchased from the power companies. Such hydroelectric power is usually supplemented by steam produced electric power generated in plants located at the mills. Paper mills are large users of steam and this steam is supplied from boiler plants burning wood refuse.

In British Columbia on the Powell River, the Powell River Co. has a modern plant with 12 boilers, furnishing 5,000,000 lb. of process steam to its paper mill. Electric power is generated by hydraulic turbines. Hog fuel burned in dutch oven furnaces supplies 30 per cent of the steam, and the rest is supplied by fuel oil, the burners being placed in the rear wall of the furnaces.

At the plant of the Washington Pulp and Paper Corporation at Port Angeles, referred to above, the bulk of the power used is generated by the company's two hydroelectric plants located at distances of 8 and 14 miles, respectively, from the paper mill. One of these plants has a capacity of 12,000 kw. in 4 units and the other 12,500 kw. in one unit. The latter is supervisory controlled from the first plant. At the mill proper at Port Angeles, a steam plant is installed with a generating capacity of about 6000 kw. Steam at this plant is produced by 5 boilers with various ratings from 400 to 1000 hp. The fuel used is mostly wood but oil is used as a standby, all furnaces being arranged to burn either wood or oil in combination.

Most of the wood fuel is obtained from sawmills in the vicinity and is delivered, already hogged, in barges. This is the practice at most paper plants; while some wood refuse is produced from the timber used in making paper, there is usually not enough available to supply the needs of the boiler house.

Another new paper mill of considerable interest is the plant at the Longview Fibre Co. at Longview, Wash. This is a strictly modern plant using Stirling boilers fired by wood burning furnaces having forced draft and air-cooled walls. This plant is located adjacent to the plant of the Longbell Lumber Co., from which it obtains all its fuel and electric current to the extent of 2000 kw. A bleeder turbine rated at 2500 kw. furnishes the remainder of the electrical needs. The furnaces at this plant are unusual because of the air-cooled walls and forced draft. Most of the hogged fuel fired plants in the northwest have simple dutch oven type furnaces operating on natural draft.

Longbell Plant Has Capacity of 18,000 Kw.

At Longview, the plant of outstanding interest is of course, that of the Longbell Lumber Co. This plant, around which the city of Longview was built, has a capacity of 1,800,000 ft. daily and is one of the largest in the world. With a generating capacity of 18,000 kw., the power plant at this mill not only supplies the electrical needs of the mills but that required for logging operations in the woods, the city of Longview, the Longview Fibre Co. and at times some power is sold to the Puget Sound Power & Light Co.

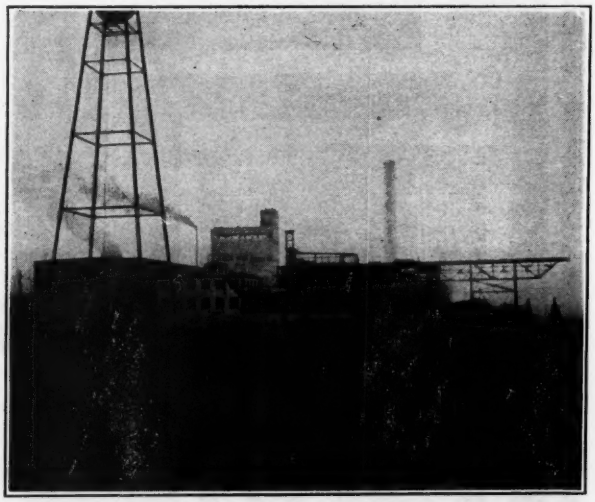


FIG. 3. THE NEW PLANT OF THE UNION BAG AND PAPER POWER CORP. AT TACOMA WILL HAVE TWO 807-HP. HOGGED FUEL FIRED BOILERS AND FIVE 456-HP. WASTE HEAT BOILERS

At this plant, power is generated by three 6000-kw., 13,200-v. turbine generators supplied with steam at 225 lb. from ten 1250-hp. Stirling boilers. This equipment is strictly modern and possesses all the refinements necessary for efficient operation. The most interesting feature at this plant, however, is the wood fuel handling and storing equipment. The fuel storage house is a large concrete building, in which an elaborate system of conveyors is provided which will deliver the hogged fuel to any part of the building and will reclaim it for delivery to the boiler plant or to the dock or railroad cars for shipment to other plants. A more detailed

description of this system will be given in a subsequent issue but the reader will obtain some conception of its magnitude from the accompanying illustrations.

New Lumber Plant for Longview

Longview itself is perhaps the most interesting town on the Pacific coast. In a short period of five years, a community for the employes of the Longbell Lumber Mills, other industries are now being attracted. The Longview Fibre Co. mentioned above is one firm of this kind. Now the Weyerhaeuser Timber Co., another large lumber interest, is building a plant on a site adjacent to that of the Longbell Co. This will be another large lumber mill and will have a new power plant consisting

FIG. 4. MORE POWER FOR SEATTLE FROM THE SKAGIT RIVER

A. The present Gorge Plant of the Seattle municipal system. B. At the new Diablo dam, showing method of anchoring dam in the sides of the canyon. C. A view showing progress of construction of the Diablo dam. D. A partial view of the construction camp at Diablo Canyon, showing the arrangement for elevation cars of concrete and fill material to the upper part of the mountain.

the Longbell Lumber Co., by means of the Longview Co., has transformed the area on which Longview stands from a wilderness, into a beautiful city of 12,000 population, with modern hotels, residences, office buildings, churches, theaters, etc. While it was built primarily as of eight 650-hp. boilers and two 7500-hp. bleeder type turbine generators. This plant is now under construction and will probably commence operation in 1929. This company is starting work on a similar plant of half the size at Klamath Falls, Oregon.

Large Wood Fired Boiler at Portland

By far the largest and most modern wood fired boiler in the Pacific Northwest, is the new 1600-hp. unit installed in Station L of the Portland Electric Power Co., at Portland, Oregon. This boiler has eight furnaces, is fired with wood refuse from both ends and is fitted with forced and induced draft fans as well as an air preheater.

It is built to generate steam at 415 lb. gage pressure and will superheat to a temperature of 725 deg. F. Air for combustion is preheated to a temperature of 450 deg. F. in a preheater having 20,000 sq. ft. of heating surface. One forced draft fan and two induced draft fans are provided. Feed water is heated to approximately 300 deg. F. by bleeding steam from the 5th stage of the turbine. This boiler supplies the new 20,000-kw. turbo-generator installed in the L St. station.

The use of such elaborate equipment where the fuel is so cheap might be questioned from a purely engineering standpoint but matters of this type are usually settled upon an economic basis. At the L Street station, it probably was largely a question of getting the greatest amount of boiler capacity into the smallest space. The station has grown considerably during recent years and it was probably less expensive to install this modern high-pressure boiler with all the refinements necessary for high capacity operation than it would have been to extend the station and install a number of small boilers.

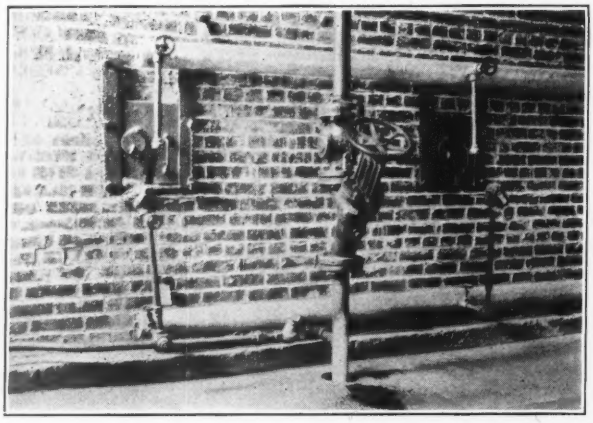


FIG. 5. MOST OF THE PLANTS BURNING WOOD FUEL ALSO HAVE PROVISION FOR THE USE OF OIL. THIS SHOWS THE ARRANGEMENT FOR THE USE OF OIL AT THE LONGBELL PLANT. THE BURNERS ARE INSERTED THROUGH THREE SLIDING DOORS IN THE REAR OF THE FURNACE

At Tacoma, in addition to the new plant of the Union Bag and Paper Power Corp., already mentioned, several new projects are under way. Two chemical plants are under construction, one that of the Hooker Electric Chemical Co. and the other that of the Tacoma Electro Chemical Co. Neither of these plants, however, will generate electricity as they will purchase all their requirements from the local power companies. The most important engineering project at Tacoma is the construction of the new Cushman Hydroelectric plant, which will increase the output of the municipal system by 45,000 hp.

Tacoma, like a number of other cities in the Northwest, is served by two power systems, one, that of the Puget Sound Power and Light Co., and the other, a municipal system of which the Cushman plant is the main source of supply.

All the lumber plants in and around Tacoma generate their own electric power and sell some of it to other industries. Wood refuse is also sold to other plants having use for it. The largest mill is that of the St. Paul and Tacoma Lumber Co. This company with an output of 750,000 ft. of lumber daily has three mills. A central power plant supplies electricity to all of the three plants and steam to two of them. Refuse fuel is also sold to a number of plants in Tacoma including that of the Consumers Central Heating Co.

At this mill, the power plant consists of a boiler house with some 3800 hp. of boiler capacity and a turbine room with two turbine generators, one rated at 2500 kw. and the other at 3000 kw. The fuel is mostly sawdust which, when it is hemlock, sometimes runs as high as 70 per cent moisture. This fuel is fed continuously into the top of dutch oven furnaces, as to permit it to pile up in the form of a cone on the flat grates below. Ordinarily, this fuel will run 30 to 40 per cent moisture.

FIG. 6. A PARTIAL VIEW OF THE ELECTRIC FEEDWATER HEATER AT THE SPOKANE CENTRAL HEATING CO.

This shows the top of the open heater. One of the three electrodes can be seen at the lower left. The position of these electrodes is controlled from the boiler room floor. Because of the steam issuing from the open tank, it was almost impossible to obtain a good photograph.

All of these lumber plants are of considerable in-

terest because of the entirely different attitude of the operators toward the value of fuel, as compared to eastern practice. The fuel is cheap and the main object is to burn it—efficiency being a secondary consideration. Of the equipment, the conveying systems for handling the wood refuse are interesting. Each plant is different in this respect and often the conveying systems incorporate a great deal of ingenuity.

Wood fuel is measured in terms of *units*, a unit being approximately 200 cu. ft. and capable of evaporating from 7000 to 11,000 lb. of water, depending upon the efficiency of the furnaces and boilers.

Like Tacoma, Seattle also has two power systems: one, the Puget Sound Power and Light Co. system and the other the municipal system. This feature of having two competing power systems serving a single community is one that prevails in a number of the Pacific Coast cities. In most cases, it consists of a municipal system competing with a public utility system but sometimes as in Portland, Oregon, there are two separate private companies.

While this serving of a single community by two systems undoubtedly makes for duplication, both of equipment and effort, and is not conducive to high efficiency, there seems to be a prevailing belief that such competition is favorable to the establishment of low power rates. However that may be, there is considerable rivalry between the proponents of the opposing systems and neither side is willing to concede much to the other.

New Hydroelectric Plant on Skagit River for Seattle

Electrical energy for Seattle is supplied by the hydroelectric plants of the Puget Sound Power and Light Co., on the Baker River, White River, at Snoqualmie Falls and other smaller plants. Municipal power comes from hydroelectric plants at Cedar Falls and on the Skagit River in the Cascades, as well as from a steam plant in Seattle. The Cedar Falls plant has a total capacity of 24,600 kw. and the George Plant on the Skagit River with a recently installed new generator now has an installed generator, a capacity of 78,000 hp. At the present time, however, the city is constructing a second hydroelectric station on the Skagit River to be known as the Diablo plant, where it is planned to install three 30,000-kw. units, two of these to be in operation by 1930. The dam at Diablo canyon is now under construction and will be one of the highest dams in the world. The construction of this dam is an engineering feat of considerable magnitude.

The abundance of hydroelectric energy in this part of the United States is reflected in the low prices at which electricity is sold. In Seattle, the residence rate after the first 40 kw-hr. at 5½ cents, drops to two cents and after the first 240 kw-hr. to 1 cent per kw-hr. Industrial rates are correspondingly low.

Naturally, with such low power rates, it is not to be expected that there would be many isolated plants. This is particularly true in the larger cities, where the private plant is the exception. Office buildings and institutions nearly all purchase current and if a central heating plant is available, also purchase steam. Central heating plants are to be found in most of the larger cities.

The low power rates have greatly stimulated the use of electricity for heat for cooking and baking and the electric range is becoming more popular than the gas range.

In spite of the wide use of hydroelectric energy, the potential water power resources of the Pacific Northwest have scarcely been touched. Hydroelectric power in Washington, Oregon and Idaho unharnessed aggregates over 20,000,000 hp. or some 38 per cent of the entire available water power in the United States. The State of Washington alone has maximum available water power resources amounting to 8,647,000 hp. and a minimum of 4,932,000 hp. Of this only 454,356 hp. has been developed. In Oregon, the maximum potential hp. is 6,613,000 and the minimum 3,148,000 hp. In this state, 185,215 hp. has been developed.

In Canada, the province of British Columbia has water power resources estimated at 1,930,000 hp., minimum and 5,100,000 hp. for 6 mo. of the year. Of this 460,562 hp. has been developed.

In Canada, also, the cities obtain their power from

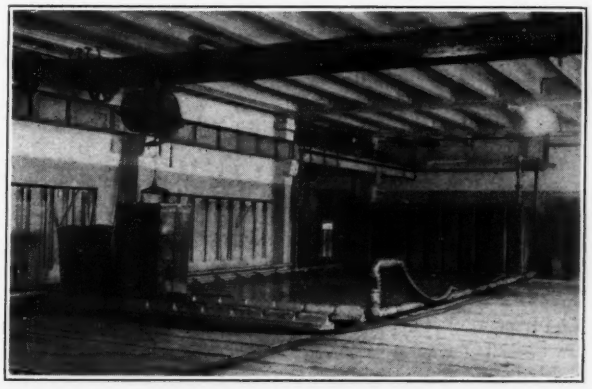


FIG. 7. PULLING ICE AT THE BOOTH FISHERIES REFRIGERATING PLANT IN SEATTLE

hydroelectric developments. Vancouver draws its power from three water power developments, two taking water from Coquitlam Lake, having a combined capacity of 84,000 hp. and the third, located on the Stave River, a capacity of 75,000 hp. A further development on Alonette Lake, of 10,000 hp. under automatic control from the Stave River plant, will soon go into operation.

Victoria, the provincial capitol, and the surrounding district obtains the bulk of its power from the Jordan River, where approximately 25,000 hp. is developed under a head of 1145 ft.

Refrigerating Plants Are Numerous

Because of the mild climate and the production of perishable foods, there has been considerable activity in the refrigerating field in the Pacific Northwest. While many of the plants date back from 10 to 30 yr. and still have the original equipment, there are also many new plants using the most modern types of refrigerating equipment.

In Seattle, the Port of Seattle has two main refrigerating and cold storage plants, the largest being that at the Spokane Street Terminal. This plant comprises three self-contained buildings, the general cold storage warehouse for the storage of perishable commodities of

all kinds, the fish and ice storage building and the compressor building containing also the ice making tanks. The ice storage building here has a capacity of 5000 tons. Refrigerating equipment consists of three, horizontal, double acting ammonia compressors each having a capacity of 110 tons.

Other large refrigerating plants in Seattle are these belonging to the Western Dairy Products Co., the Diamond Ice and Cold Storage Co. and the Booth Fisheries. A new public skating rink is also under construction, which will have a refrigerating plant of considerable magnitude.

A number of plants in the Northwest are using the brine system of spraying coils and are finding it successful. In this system, brine is sprayed over the ammonia coils at intervals which keeps them defrosted. The brine is pumped from the main brine tanks.

Cheap Electricity Promotes Use of Electric Boilers

Because of the abundance of cheap hydroelectric power, a number of plants are using the electric boiler, as a supplementary source of steam supply. Where current is available, the electric boiler is an ideal piece of apparatus. Its compactness permits its installation in places where an ordinary boiler could not be installed and the entire absence of need for fuel makes its operation almost automatic.

At the plant of the Spokane Central Heating Co. in Spokane, is installed not only an electric boiler but also an electric feedwater heater. This company is controlled by the Washington Water Power Co., and since there is usually an excess of hydroelectric power, the operation of the electric boiler and feedwater heater becomes possible. This is an extremely interesting plant and a more detailed description will be presented in a future issue.

This electric feedwater heater is operated at 4000 v. and is of the 3-phase, electrode type. It will heat 150,000 lb. of water per hour to a temperature of 212 deg. The arrangement is simple, consisting merely of an open tank with three electrodes at the top. The electrodes can be raised or lowered with respect to the water level, from the boiler room floor.

This plant burns sawdust in suspension. The furnaces are of the dutch oven type fitted with underfeed stokers for use with coal but when sawdust is available, this is burned alone. It is significant that on a rather extended trip from Vancouver down the coast to Portland and then east to Spokane, this was the only steam plant visited by the writer where coal was used at any time.

Boiler Furnace Refractory Investigations

Common Misconceptions Reviewed and Much Valuable Information Given in this Practical Discussion of a Little Known Subject. By C. F. Hirshfeld* and W. A. Carter*

FOR PURPOSES of discussion, boiler-furnace refractories may be classed simply as firebrick; and firebrick, in turn, as a chemical mixture which, after being molded and burned, is resistant to furnace temperatures. There are certain other materials, known as plastics, which fall under this heading but they will not be considered at this time.

It is customary to speak of certain properties of firebrick, although little is known of the real significance of these properties which are: 1, fusion temperature; 2, resistance to spalling; 3, density; 4, porosity; 5, comparative strength hot; 6, change of volume under repeated heating and cooling; 7, resistance to slag erosion; 8, thermal conductivity; 9, chemical composition; 10, dimensional tolerance; 11, uniformity; and 12, color.

Inasmuch as the real significance of few of these factors is appreciated, it is perhaps well to review briefly certain misconceptions and in that way bring out the general lack of knowledge with respect to the different characteristics.

Fusion Temperature Seldom Exceeded in Service

Many people think that high fusing temperature is the only property that must be possessed by a firebrick. Practically all good firebrick will fuse in the neighborhood of 3100 deg. F. or higher, while carefully made measurements show that the temperatures to which they are subjected in the furnace will vary from 2600 to 2800 deg. F. So high temperature does not have the significance that many people think it has or the significance that they try to give it.

Distortion when Hot Is Important

Cold crushing strength of a brick is frequently determined but means little because any brick when cold is strong enough to support any load that boiler construction will place upon it. Compressive strength when hot is of more value and the one important test is the amount by which they distort or compress under a compressive load when hot. If it is assumed that the inner ends of the brick in a furnace are at a temperature of 2500 to 2800 deg. F. and laboratory tests be made at this temperature, the compressive strength will be so low as to bring doubts as to whether or not such a wall could possibly stand up in service. The fact is that only a small part of the brick is at this temperature. The temperature gradient is steep at or near the furnace side so that the greater part of the load of the wall is taken by the cooler brick outside of the immediate inner layer.

Temperature Changes or Pinching May Cause Spalling

Spalling is a widely and loosely used term. The common conception is that a firebrick should have such characteristics that it does not break apart or spall when subjected to widely varying temperatures. The fact is that the same type of breaking can occur from a number of different causes, one of which is rapid change of temperature. The cause may be purely mechanical such

*Detroit Edison Co., Detroit, Mich. From a paper presented at the Second National Fuels Meeting of the A. S. M. E.

as being pinched by the wall construction. When subjected to pressure, the corners break off at curious angles. Again, the mixture of slag and brick or fly ash and brick may give different coefficients of expansion to the different parts. It is best to regard spalling in a broader sense as any breakage which results in the inner end of the brick falling off.

Then there is slag erosion which occurs without spalling and the common conception is that the brick is melting away. As a matter of fact, the brick is being dissolved by the ash and a higher melting temperature brick is not the solution. It is difficult to find a brick that will give trouble by actually melting away.

Some feel that it is a good idea to arrange the design so that slag will collect on the inside wall and protect the brick. There are some unique conditions where this is advantageous but, in general, the accumulation of slag is not advantageous.

Porous Brick Subject to Slag Penetration

Some assume that a dense brick is the one to use because of the resistance offered to slag penetration. Dense brick has certain advantages but the more dense the brick the more subject it is to other diseases such as, for instance, breakage under temperature changes. Another school holds that porous brick is preferable because it does not spall. Where spalling is the governing factor, this is true but where slag penetration is causing the trouble, it is not. It is impossible to make a universal rule; you may say, "For my particular coal or load conditions a dense or porous brick is best," but you cannot say that for the country at large.

Color Meaningless Except Under Unusual Conditions

Many feel that it is possible to determine the value of firebrick from chemical analysis. Unfortunately, this is not true, although we are getting to the place where it is possible to form certain ideas under certain broad conditions. Color, which is generally assumed to represent the amount of iron, can be changed by treatment in the kiln and unless one is skillful and knows the burning process, color means little except in this sense: if you get a batch of brick from one manufacturer from one clay, baked at the same time, uniformity of color represents a uniformity of conditions throughout and is advantageous in this sense.

Reducing Atmosphere Changes Slagging Conditions

In some places, it is felt that gases in the furnace are oxidizing; in others, that they are reducing and theories of firebrick performance are based on the assumptions made. Observations in the field indicate that with sufficient excess air to give good combustion, it is still possible to have highly reducing conditions at the wall. This reducing atmosphere makes slagging conditions more serious.

Again, determinations of the composition of the coal ash before burning, or the slag in the ashpit, are of little value in determining the composition of the slag at the wall. Certain constituents of the coal ash pass out with the gases so that there is a separation; some quantities find their way to different places in greater quantities.

Many factors, such as the composition and velocity of gases at the walls, that have an important bearing on this subject have been studied, although as yet no exact evaluation can be made. We found no technical method of choosing firebrick, even though the service to be met was known. The only method is to buy brick and build enough of a sectional wall to give a reasonable test in service.

Many men have pet hobbies with respect to the use of refractories while many have ideas based on more or less imperfect observation. You cannot argue from what we now know of firebrick as to what should happen to them in the furnace or the best way of using them in the furnace. There is no royal road to the choice of firebrick and no royal road to the use of it after you have found it and built it into the furnace.

Among boiler furnace operators, you find that each builds a furnace according to his own notions and it is impossible to find out which is better or why. You find it impossible to determine the actual behavior of refractories in service because people have not kept records or made complete observations. People test two brick in two adjacent furnaces under the same load and say, "This one is good" or "This one is bad"; if you have sufficiently detailed records, you will find the one furnace operated under entirely different conditions not apparent to the fireman but quite different in their effect on the brick.

In 1924, we were faced with this sort of thing and formed a committee to investigate this subject. We arranged with the Bureau of Mines and later the Bureau of Standards to coöperate with us. Toward the latter part of 1925, we persuaded the A. S. M. E. to make us a special research committee.

The first part of the investigation was to determine the conditions under which firebrick were used; that is, the conditions of service. Investigations by the Bureau of Mines in some 34 large central stations and the Bureau of Standards in their laboratory have brought out some interesting and valuable points.

Four Oxides Must Be Dealt With in Varying Quantities

In that end of the fire brick adjacent to the fire, oxides of four different metals must be dealt with. Nobody knows what the melting points of these oxides are when they exist in different relative proportions. So far we have covered a small part of the field but before we get through we hope to say, "If you have this particular combination present, the best you can hope to do is get a fusion temperature not higher than this and to change that, you are going to have to change the quantity of one of those present."

We have also arranged for coöperation with the Ceramics Laboratory at the University of Illinois and they are attempting to produce and prove the value of a laboratory type of test for determining the resistance of brick to certain furnace conditions. In the future, after we have learned a great deal more than we know now, we propose to take a certain number of brick arranged to vary one factor at a time.

Firebrick comes in many sizes and in general the larger the individual brick, the better, provided it does

not lead to manufacturing difficulties or difficulties from temperature changes in the furnaces. Unfortunately it is difficult to get large sizes as well made as the smaller ones because of the difficulty of mixing and the possibilities of cleavage planes caused by air, oil and foreign matter.

In most cases, this drives us down to the use of smaller shapes. Firebrick walls may be regarded as made of an inner layer which is there to take the hard service and an outer layer placed there for other reasons. For structural and air infiltration purposes, brick sizes for the inner wall should be chosen so that after construction the joints do not line up.

Unless financial conditions demand, it is better to use firebrick throughout rather than a mixture of firebrick and common brick. When the wall gets hot, it expands as a unit but when cooled, it contracts by individual bricks. When possible, it is best to build the wall of brick so placed and selected that they will have the same coefficient of expansion from the inside to the outside. The life of the wall will depend upon how closely this condition is met.

Arrangement of Expansion Joints Should Be Carefully Considered

Particular attention should be paid to expansion and contraction and the construction of expansion joints to take care of it. One school favors the use of ashless corrugated paper between each two bricks. The paper burns out, leaving the crack for expansion; but unfortunately this crack tends to fill up with slag and the expansion joint vanishes. As a result, slag is in a position to act on the side of the brick and cause deterioration. Another school favors the use of expansion joints in the corners only. This takes care of expansion but because the walls cannot be reënforced to give them tensile strength, contraction cannot be taken care of. It is best to have expansion joints every 5 or 6 ft. if it can be arranged.

These joints should be wide, about an inch to 1½ in. and should be packed with mineral wool. This joint should be through the entire wall but not, of course, as a continuous opening. It might seem that this type of joint does not improve the situation; however, the fact of the matter is that there is so wide a gap in the brick that the slag will crack down the joint as the furnace cools. This slag tends to hold the bricks between the joints together and give them a tensile strength the wall did not otherwise have. This is, of course, only a relative condition.

In general, if the surface of brick covered with slag be heated up and cooled down, the slag on the surface will contract more rapidly than the brick beneath it, so that, in a surface between joints, there is a tendency to pull apart. As compared to a surface without joints, however, the situation is much better. Again this condition is relative only.

Bricks Should Be Placed Close Together

There has been much argument with respect to the thickness of the joints, some advocating placing the brick face to face as tight as possible. The other extreme is a wide joint made by some sort of fire clay or cement. So far as our observation is concerned, the thinner the joint the better the job and our practice is to lay brick to brick as nearly as it can be done. This means grinding the face of the brick and then dipping it in a thin slurry made of small particles which will remain in suspension and which will not keep the brick apart when placed one on the other. In building a furnace wall, you are almost certain to have slag and it is safest to assume that the slag will penetrate into any joint or crack which exists.

Correction of Trouble Is Sometimes Easily Accomplished

If slag erosion is the controlling factor in the life of the brick, the first solution is to try to find a combination of brick and coal that will not give you the same result. Frequently this cannot be done but there are a number of ways in which conditions may be bettered if not completely cured.

One possibility is to reduce the velocity of the gases as much as possible, although people do not ordinarily think of gas velocity except in the passes of the boiler. Sometimes it is difficult to reduce the velocity if a certain amount of coal must be burned in the furnace of a given size. These are, however, places where changes can be made, as for instance, tipping or raising the arch or, if using a stoker narrower than the boiler, as frequently happens now that we are getting stokers so long that we do not have to use the whole width of the boiler, it may be possible to run the walls up an angle and thus decrease the velocity materially.

Reducing the velocity has two effects: first, decreasing the amount of flyash and second, decreasing the blasting effect which the passage of the gas over slag of low viscosity may have. Slag having low viscosity will stick until so thick and then the outer surface will blow away. If the surface be subjected to high velocity gas, it is obvious that it will blow clean, subjecting the wall to continuous erosion.

Oxidizing Atmosphere Improves Conditions

Another method of preventing slagging difficulties is to change the character of the gas and this method is often used, although frequently not understood. If a reducing atmosphere at the face of the wall be changed to an oxidizing atmosphere, the fusing temperatures of the materials that are melting and running away will be increased.

Side wall tuyeres and air cooled blocks are used for that purpose but most people think of them merely as parts of an air-cooled wall, consequently not easily brought up to high temperature. That, however, is but part of the story. If the air cooling them is allowed to pass up the wall above them, it gives an oxidizing effect which would not otherwise exist and cases are known where, after introducing such conditions, slag erosion has been partially or completely stopped. One method, therefore, is to cool so that the parts will not come up to fusing temperature and the other is to introduce air so as to change conditions at the desired point.

Still another method and one which was not well understood until a few years ago is to change the position of the wall so that it receives less radiant heat and radiates more heat. This is not so easy to do after

the furnace has been built as it is to do when the furnace is first designed.

There are certain possibilities in the uses of special brick such as carborundum. These bricks are expensive but have the advantage of not forming so fusible a slag, or, sometimes with certain types of fly ash, no slag at all. This is not a cure-all, however, and must be used with knowledge. Still another possibility is the use of small sections of water-cooled surfaces. Putting in a small section of water-cooled wall, however, does not mean building a water-cooled furnace.

Sometimes Methods of Facilitating Repairs Is Only Recourse

If matters cannot be improved by these means or the means are not available in special cases, there is only one answer and that is to arrange things to replace easily and cheaply the part that wears out. Putting an arch above the wall to carry the weight above and not bonding the part that wears out too perfectly to the part outside, facilitates making these changes and although in a certain sense this is not a cure, it is a means to an end and helps keep the boiler in service.

Shelves in general should be avoided; they collect slag and with a rise in temperature, this melts or blows down in a huge avalanche which can cause all kinds of trouble.

Relieving arches should always be used in high walls if for no other reason than to break the wall into pieces. Double arches are also of advantage; the hot part is subjected to practically no load and the expansion joints below can be put into advantage. Suspended walls are also of advantage in many cases, although not universally applicable.

Construction and Fuel Economy of Large Boilers

Possible Increased Efficiency, Lower Costs and Better Control Gradually Push Boiler Sizes and Ratings Toward the Ultimate Limit of One Boiler for Each Turbine

REGARDLESS of criticism and predictions of construction, operation and maintenance difficulties, the decided trend toward larger boilers, higher ratings and higher pressures continues at an ever increasing rate.

Fundamentally the large unit offers possibilities of fuel efficiencies, low construction costs, lower maintenance costs, ease of operation and improved control that can never be reached by small units. Good heat absorption requires large economizer, or, a combination of economizer and air heater surfaces, good combustion conditions require carefully proportioned, well designed furnaces and fuel burning equipment, high boiler ratings require adequate draft equipment, while economical and efficient operation over long periods is made possible only by automatic control.

In large units, refinements and additional equipment to increase the efficiency even a fraction of a per cent are justified because of the large quantities of fuel involved and the relatively lower construction costs per unit of capacity. In Boiler No. 5, Unit 4 at Crawford Avenue Station, the gases are cooled, by means of an economizer and air heater, to a temperature of around 250 deg. F., or approximately 250 deg. F. lower than the saturated steam temperature in the boiler drums. In fact, over the range of 100,000 to 160,000 lb. of steam per hour, the gas temperature leaving the air heater does not exceed 280 deg. F., indicating the extent to which designers are justified in going to reclaim heat in units of this size.

Both Output and Reliability Must Be Considered

Construction costs of buildings used to house the units are also an important factor and will run somewhere in the neighborhood of 25 per cent of the total cost. Building costs are usually based upon the cubical contents and as a given boiler capacity can be installed in a smaller space if large units are used, the first cost economy of such boilers is self evident.

Often the importance of first cost is lost sight of in the race for higher efficiency. That this condition should not exist is brought out forcibly by costs of Cahokia Station, where notable progress has been made in lowering both operating and fixed charges. In the No. 3 unit installed in 1923, the boiler room operating charge per ton of coal burned was but $0.961 compared with a fixed charge of $4.62 per ton. In the latest units, the operating charges have been reduced to $0.563 per ton of coal burned and the fixed charges to $2.18. The important point is that in each case the fixed charges are over four times the operating charges.

What Mr. Tenney terms the "service capacity factor," a term involving both the maximum boiler rating and the total hours the boiler is available for service, has been increased from 136 to 328, representing a saving of $2.84 per ton of coal burned. The advantage of high ratings and dependability is self evident. Large units, by justifying refinements, make the attainment of both of these conditions easier. Absolute dependability over long periods of time can be assured by operating at low ratings or high ratings can be obtained at the expense of reliability. The problem is to find the point between these two extremes where the total cost of steam will be the lowest.

In this day of high ratings, boilers must be considered not alone but in relation to all of their auxiliaries. Naturally, if the rating at which the boiler can be operated is doubled, the result, from a steam production standpoint, is the same as if the boiler were doubled in size and operated at the lower rating.

Water Walls Allow Boiler Ratings to Be Increased

It is in this connection that the value of boiler auxiliaries is realized. Water walls, forced and induced draft fans, economizers and air preheaters all have their place in modern design. Water walls are expensive when measured on a square foot basis, yet they are called the cheapest boiler surface available, not because of their direct steam making capacity but be-

cause they are the means of operating the boiler at higher capacities.

As yet, the steam producing limit of a square foot of heating surface has not been determined and the major factor in the steam making capacity of the modern boiler is the amount of fuel that can successfully be burned in the furnace. This, in turn, depends upon a number of factors such as: 1, available draft; 2, slagging of the lower rows of boiler tubes; 3, furnace

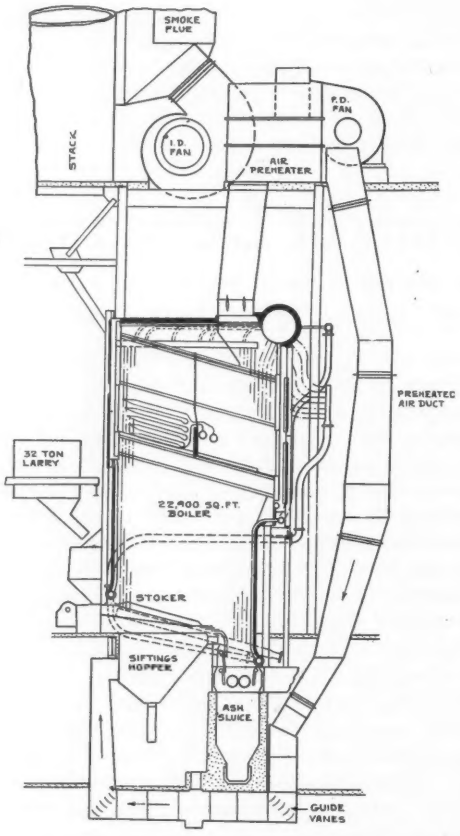


FIG. 1. AT KEARNY, THE NEW 22,900-SQ. FT. BOILERS, EXCLUSIVE OF SUPERHEAT AND WATERWALLS, WILL BE FIRED BY UNDERFEED STOKERS

maintenance; 4, smoke; 5, losses due to incomplete combustion; and 6, fuel handling and burning equipment.

Some of these factors depend upon the quality of coal, some upon the station design and equipment design; others depend upon a combination of the two. With high drafts, particularly, a low fusing temperature ash will give trouble by slagging up the lower rows of boiler tubes, reducing heat absorption in the first rows and constricting the gas passage. In many cases, this difficulty has been controlled by the effective use of slag screens, placed before the boiler tubes. The function of this screen is to reduce the velocity of the gases entering the first row of tubes and also to cool the gases, consequently the entrained slag, to a point where this slag is not plastic and will not adhere to the tubes.

By making possible larger furnaces, larger, more efficient auxiliaries and effective water-cooled walls, large boiler units offer greater possibilities in design and operation. This trend is not by any means confined to central stations, as an analysis of industrial plants fired by pulverized coal shows that the average direct fired boiler in the neighborhood of 400 b.hp., around 1920 or 1921, has increased to about 800 b.hp. With the central system, the increase in size has been about in the same ratio; the average size, about 600 hp. in 1920, has increased to about 1200 hp. Central station boiler sizes are larger and have increased in size somewhat faster.

At present, boiler units capable of supplying 300,000 to 400,000 lb. of steam per hour are available and many engineers favor the development of boilers to a point where each turbine will be supplied by one boiler. The obvious disadvantage of such a design is the high overhead when the boiler is out of service for repair or cleaning.

This disadvantage, just as applicable to large turbine units, has not been sufficient to hamper the devel-

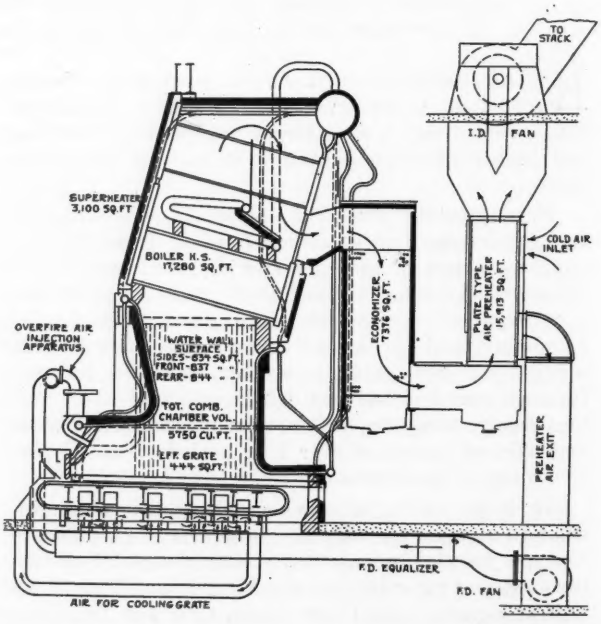


FIG. 2. ARRANGEMENT OF THE NEW BOILER UNITS AT CRAWFORD WHERE CHAIN GRATE STOKERS AND OVERFIRE AIR INJECTION ARE USED. BOILER HEATING SURFACE, 17,280 SQ. FT.; ECONOMIZER SURFACE, 7376 SQ. FT.

opment of large generating units where the character of the load will justify their installation. Such a unit station design, if carried out, would demand the same reliability and length of operation from the boiler unit as from the turbine, a condition not ordinarily encountered but which is not by any means impossible.

Such long and continued operation depends upon good design and workmanship of equipment, close attention to known weak parts, careful operation and above all, good feedwater. These factors are controllable but the degree of control and supervision that can be economically given is greater for larger size units and, as such, these large units offer a decided advantage.

As a rule, furnaces bear the brunt of long continuous high rating periods of operation. Water walls now used for at least portions of all large furnaces give them a decided advantage in the matter of control and maintenance. With refractory walls, the limit of furnace wall size was quite definite and if continued in the large furnaces of today furnace maintenance would be high. Water walls and suspended or sectionalized air-cooled walls give better service even under the severe conditions of modern operation. Furthermore with increased furnace size, the volume increases faster than the wall area and this volume can be utilized to better advantage than it could if split up into a number of smaller furnaces.

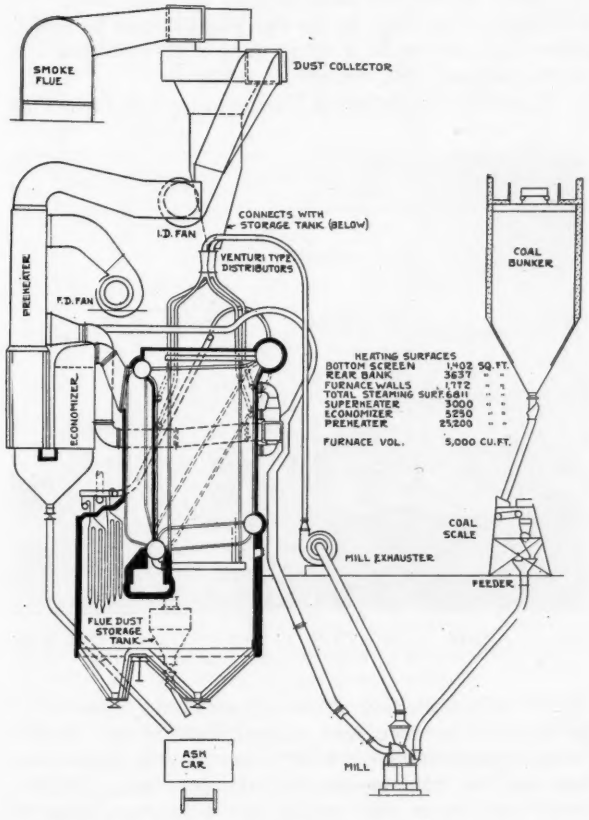


FIG. 3. ARRANGEMENT OF BOILER NO. 20 AT CALUMET STATION. A SMALL UNIT DESIGNED FOR OPERATION AT HIGH RATINGS

Increased Size Common to All Fuels and Boilers

All types of boilers fired by the three general classes of fuel—coal, oil and gas—are subject to this trend toward larger sizes. Some of the most recent designs are illustrated.

At Kearny, Fig. 1, the new 22,900-sq. ft., 350-lb. boilers are fired by 500-sq. ft., 15-retort underfeed stokers. A somewhat different arrangement of equipment is illustrated by Boiler No. 5, Unit 4, at Crawford Avenue Station, Fig. 2. This is a forced draft chain grate fired unit using overfire air injection, an economizer and air heater.

At Calumet Station, boiler No. 20 shown in Fig. 3, is designed for a high steam output, 150,000 lb. per hr., from a relatively low steam producing surface. The total steaming surface is 6800 sq. ft. divided as shown in the illustration. In addition, there is a 3000-sq. ft. superheater, a 5250-sq. ft. economizer and a 25,200-sq. ft. air heater. The furnace volume is 5000 cu. ft.

Although these units differ widely in design and arrangement, they are all built to accomplish the same thing, that is, produce steam at the lowest possible cost. As such, operation, maintenance and fixed charges were considered and the refinements which are justified in boilers of this size are evident from an inspection of any of the illustrations. They all show the extent to which designers of large boiler units are justified in going to increase the efficiency of a unit even a small amount. In small units, this refinement is not justified because of the smaller quantities of heat dealt with. Figure 4 is drawn from a number of boiler tests taken from authoritative sources and shows the gradual increase of average boiler efficiency with size.

Just where the dividing line between large and small boilers should be placed is indeterminate. What would be a large boiler in one plant might be a small one in another. Load conditions, type and cost of fuel, quantity of steam needed, necessity for continuous service and the cost of installation must be taken into consideration.

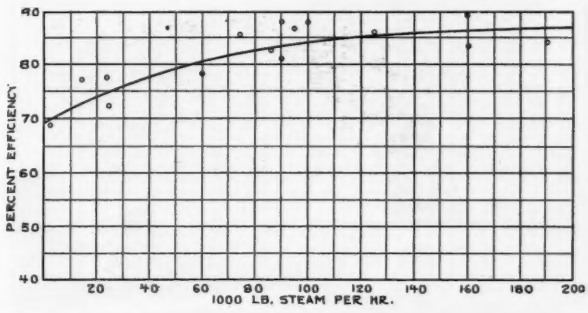


FIG. 4. PUBLISHED TESTS ON BOILERS OF VARIOUS SIZES SHOW INCREASED EFFICIENCY OF LARGE UNITS

Obviously, factors other than economy of operation must be considered and cases where the installation of a single unit to supply the entire steam demand of a plant would be justified are rare. In general, under the same conditions with the same standards of engineering, the larger the boiler units the greater the economy of both installation and operation. Boilers should, therefore, be the largest possible compatable with the size of the plant and operating conditions while the total steam requirements should be divided among a number of units so as to give the maximum insurance against interruption of service and at the same time give the maximum degree of flexibility.

According to a report from the Department of Commerce, new orders for 1649 steel boilers were placed in August as reported by 72 manufacturers, comprising most of the leading firms in the industry. This compares with 1615 boilers in July and 1517 in August, 1927. During the first eight months of the present year, there were a total of 10,897 stationary boilers sold with a total heating surface of 10,213,678 sq. ft.

North Dakota Lignite Burned in Kidder Station

CHAIN GRATE STOKERS AND PREHEATED AIR EMPLOYED TO BURN SUCCESSFULLY THIS LOW-GRADE FUEL. BY ARNE ARNESON*

KIDDER STATION of the Otter Tail Power Co. is located on the Red River of the North, about a mile from the city of Wahpeton, North Dakota, and about three quarters of a mile from the Fargo branch of the Chicago, Milwaukee and St. Paul Railroad.

At present two 7500-sq. ft. Badenhausen boilers, each fired by two 8 by 16-ft. Harrington chain grate stokers, are installed. Each boiler has a 1243-sq. ft. Badenhausen superheater, a 6950-sq. ft. Badenhausen-Bohn air preheater, a Sturtevant Turbovane forced draft fan and a Sturtevant Multivane induced draft fan, all fans and stokers being motor driven. The arrangement of this equipment is shown in Fig. 4.

Steam is generated at 350 lb. pressure and a total temperature of 625 deg. F. The air for combustion is preheated to 300 deg. F. as this is necessary in order to obtain high boiler ratings with the coal used. No economizers are used, as the flue gases cannot be cooled below the dew point without danger of corrosion due to the high sulphur content of the coal.

Lignite mined in North Dakota is used as fuel. This lignite is a soft coal of woody structure which may be classified between peat and sub-bituminous. It contains approximately 6500 B.t.u. per lb. and has a moisture content ranging up to forty per cent. With a good load factor, the station can generate a kilowatt hour on 3.5 lb. of coal.

Coal cars delivered to the station over a spur track are spotted over the track hopper and dumped; coal is crushed to three quarters inch size by a Jeffreys 18 by 18-in. single roll crusher; conveyed by a Chain Belt Co. bucket elevator to overhead bunkers and then spouted through a Chain Belt Co. weigh larry into the stoker hopper. Ashes are removed by an Allen-Sherman-Hoff Hydro-Jet, sluiced into a sump and pumped outside of the station.

Electric power is generated by a General Electric 3000-kw., 2400-v., 3-phase, 60-cycle unit set over a Worthington two-pass horizontal surface condenser. One motor driven centrifugal condensate pump and two centrifugal circulating pumps are provided, one of the latter being turbine and the other motor driven. Either pump is capable of delivering the total amount of cooling water.

At this point, the Red River contains a great deal of floating matter and a Rex motor driven traveling

*Assistant Engineer, Otter Tail Power Co.

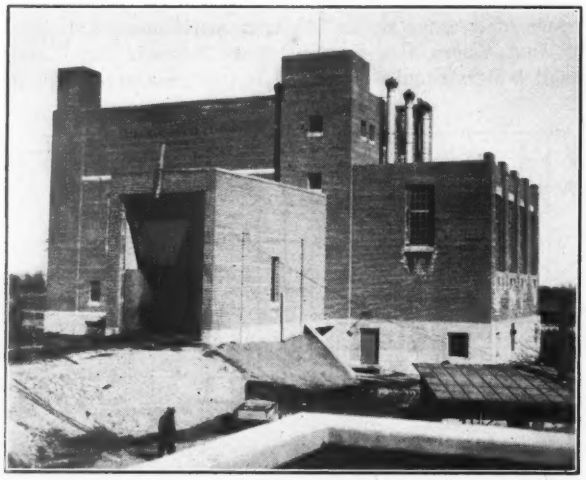


FIG. 1. EXTERIOR VIEW OF KIDDER STATION SHOWING THE ASH AND COAL HANDLING ARRANGEMENT

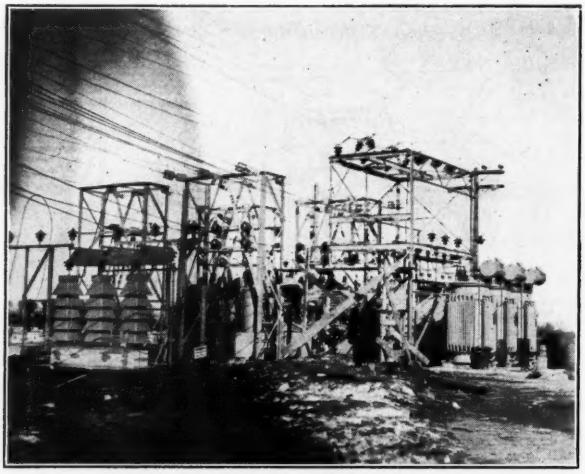


FIG. 3. THIS SUBSTATION IS CONNECTED WITH THE POWER PLANT BY A CONCRETE TUNNEL

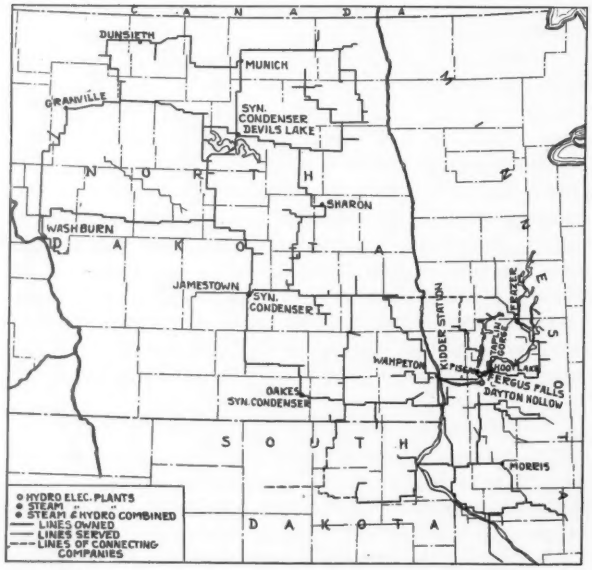


FIG. 2. TRANSMISSION LINE DIAGRAM SHOWING THE TERRITORY SERVED BY THE OTTER TAIL POWER CO.

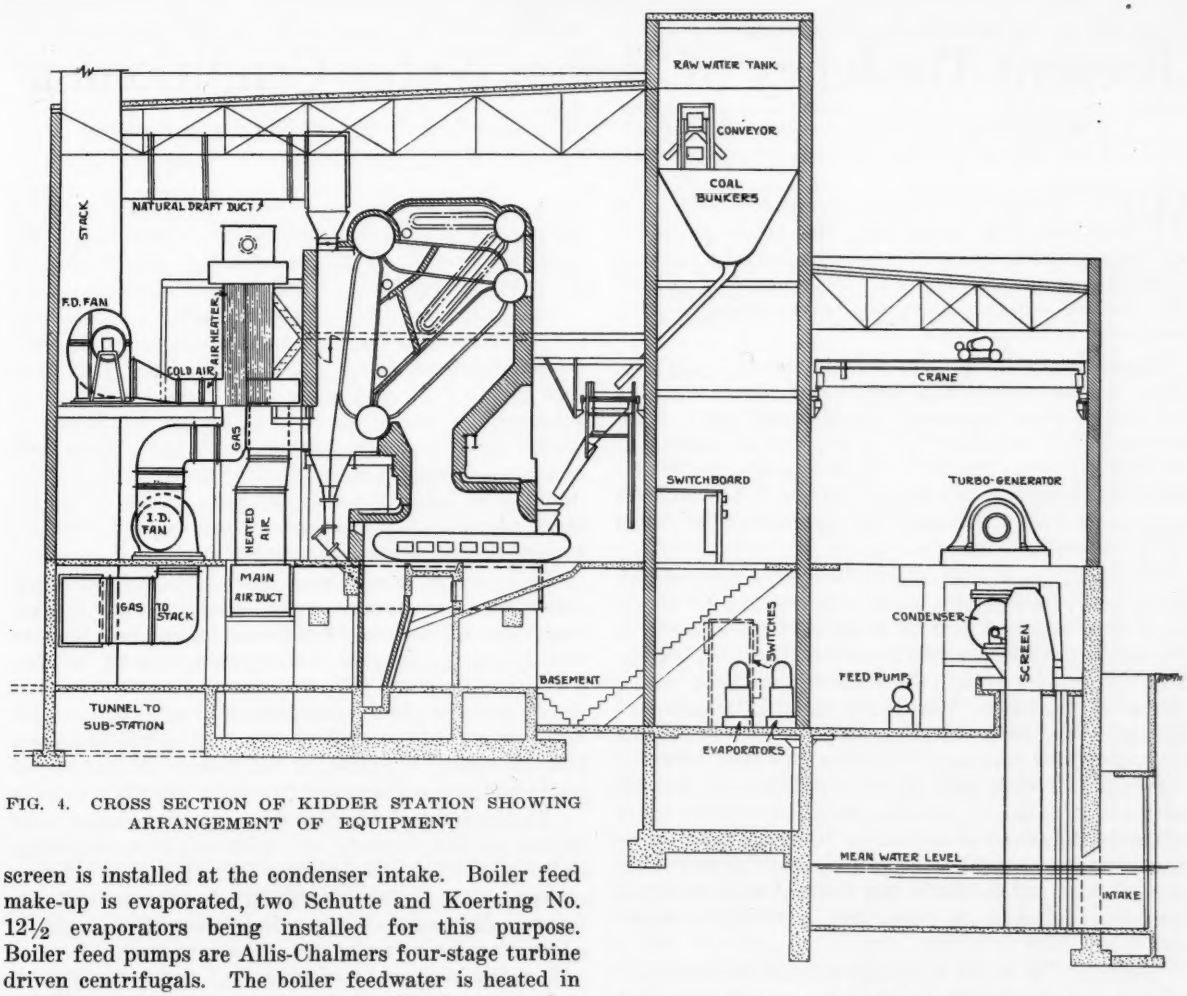


FIG. 4. CROSS SECTION OF KIDDER STATION SHOWING ARRANGEMENT OF EQUIPMENT

screen is installed at the condenser intake. Boiler feed make-up is evaporated, two Schutte and Koerting No. 12½ evaporators being installed for this purpose. Boiler feed pumps are Allis-Chalmers four-stage turbine driven centrifugals. The boiler feedwater is heated in a 1500-hp. Elliott open type deaerating heater and a Schutte and Koerting evaporator condenser.

Miscellaneous equipment includes one Allis-Chalmers turbine-driven high pressure wash water and fire pump, two Worthington motor driven service pumps and two Westinghouse exciters, one motor driven and one turbine driven.

Long Transmission Lines on System

A steel substation, shown in Fig. 3, is located approximately 100 ft. from the power house and connected with it by a concrete tunnel. At present, the substation serves three transmission lines but provision has been made for a fourth.

This station is one of a series of 10 steam and hydro stations feeding a system of approximately 3000 mi. of transmission line, the longest of these lines being about 250 mi. The load on this system is light and scattered, mainly lighting, with a little power. The system peak load is about 13,000 kw. and the total installed capacity of these 10 stations is about 18,000 kw.

In a system of this type with long transmission lines, the lines are not fully loaded at all times. Over the peak, unity power factor can be obtained but during light loads there is a tendency to set up a very high leading current and a low power factor which requires a large portion of the plant capacity. For each mile of line, approximately 2 amp. of the plant capacity at 2300 v. is needed for charging the line. At advantageous points on the lines, synchronous condensers are placed to take the place of the necessary inductive load.

Details of the recently perfected nitrided steel were recently presented before the French Academy of Sciences by Leon Guillet. The nitriding process subjects special steel to the action of ammonia gas, for a period of time which varies with the depth of the case desired, at a temperature of 950 deg. F. without subsequent quenching. This special steel, known in this country as Nitralloy Steel is being manufactured by the Central Alloy Steel Corp. and the Ludlum Steel Co. under special American rights to the patent.

This nitrided case which hardness tests show to be as high as 900 to 1100 Burnell is fully as resistant as the best stainless steel to corrosive action when placed in salt water or in moist atmospheres. Wear tests upon nitrided steel shows that it is much superior to any other steel in its resistance of metal to metal wear. The steel employed in a particular specimen shows the following analysis: C. 0.35, Gr. 1.60, Al. 1.20. The metal after quenching and drawing to a temperature above 1100 deg. F. showed a tensile strength of over 125,000 lb. per sq. in.

Present Tendency of Boiler Water Conditioning

PREVENTION OF SCALE, CORROSION AND EMBRITTLEMENT AND THE PRODUCTION OF DRY STEAM DEMAND DEFINITE RELATIONS WHICH MUST BE MAINTAINED THROUGHOUT THE CYCLE. BY R. E. HALL*

WITH A NEW era of large-sized boilers, high pressures and high rating has come the necessity for assured continuity of operation, engendered by the considerable percentage of plant load dependent on each unit and the demand that steam be uncontaminated by carry-over of boiler water.

There has been a time, and not many years ago, when it was considered unorthodox to extend the province of water treatment beyond furnishing a standard softened feedwater of a guaranteed degree of residual hardness. In direct contrast thereto, water conditioning today does not end its responsibility until the steam is returned to the boiler as condensate or is wasted to the atmosphere or sewer.

Since the greatest variety of natural waters, muddy and clear, ranging from highly bicarbonate to highly fixed acid, must be used as feedwater, the element of flexibility in water-treating equipment is indispensable. Elimination of corrosion in heaters, feed lines, economizers, and boilers requires maintenance of definite conditions of hydroxide alkalinity and low concentration of oxygen in water-making contact with their surfaces. Prevention of scale and caustic embrittlement necessitates maintenance of definite conditions in the boiler water. Attainment of dry steam with minimum blowdown depends in great part upon keeping the concentration of dissolved solids in the feedwater as slight as possible and free from saponifiable organic contamination.

Corrosion in steam lines and turbines is best minimized or eliminated by removal of oxygen and combined or uncombined carbon dioxide from the feedwater. At times, in industrial plants with large sudden variations in load or old boilers not specially adapted to these conditions, it is the part of wisdom to maintain, at the cost of wretched quality of steam, the better boiling conditions of slightly under-treatment than those of complete treatment. Maintenance of these various conditions is of primary importance and water-conditioning equipment should be chosen on the basis of the ease and certainty with which their maintenance may be attained.

CONSIDERABLE CHOICE ALLOWED IN SELECTION OF EQUIPMENT

Boiler water conditioning, by having defined relations that must be maintained throughout the water-cycle and by having removed all guesswork, gives the engineer considerable latitude in the choice of equipment for attaining the essential relations. Thus, dependent on the character of the raw water and the percentage of makeup, he may in one case most economically protect his economizers from corrosion by the use of deaerators and the direct maintenance of a slight hydroxide alkalinity in the water, while in another case he may better install a hot-process softener equipped with a well-vented heater, wherein both the essential removal of oxygen and the introduction of the necessary hydroxide alkalinity are attained.

In either case, protection of the boiler surfaces from scale formation is assured by the maintenance of well-defined conditions in the boiler water. For higher pressure boilers the use of evaporators for a small or even a larger percentage of makeup is not mandatory to protect the evaporating surfaces of the boiler from scale formation, inasmuch as the maintenance of definite relations in the boiler water is necessary in any event because of condenser leakage and can as well care for makeup water as for leakage alone.

Boiler-water conditioning goes farther in defining conditions whose maintenance is essential, since it takes cognizance of the characteristics of boiling and the factors influencing the rate of disruption of steam bubbles. Thus the engineer, with full knowledge of the boiler water and the load conditions with which he must deal, can attack the problems of steam-liberating space and the segregation of boiler water from the steam with confidence and make ample provision therefor.

Emphasis has been placed on maintenance of conditions as the keynote of boiler-water conditioning. Daily records give comforting assurance that the best recommendations for prevention of embrittlement are being maintained. When a leak occurs in a seam, it is unnecessary to make one or two analyses of water and on the inadequate evidence thereof to make guesses that conditions favorable or inimical to caustic embrittlement have existed. The daily records with their hundreds or thousands of analyses are indisputable evidence that either caustic embrittlement is not occurring or else all recommendations for its inhibition are wrong. The value of these daily records cannot be emphasized too strongly and constitute an essential part of water conditioning in any plant.

ESSENTIAL CONDITIONS IN THE WATER AT VARIOUS SURFACES

For the purpose of discussing the relations of water to its contacting surfaces, the complete water cycle may be broadly divided as follows: 1, surfaces in contact with water below steam temperature; 2, surfaces in contact with boiler water and steam generated therefrom, and 3, surfaces in contact with water and condensing steam. Surfaces of superheaters are not included in this classification, as they should never be in contact with boiler water and steam, and condensation of steam does not occur therein.

Surfaces in contact with the boiler water are those of the boiler proper. Their optimum protection necessitates recognition of three separate factors affecting them each in its particular way, namely (*a*) loss of metal, (*b*) scale formation and (*c*) caustic embrittlement. Defense against each of these factors requires continu-

*Director, Hall Laboratories, Pittsburgh, Pa. From a paper presented before the Second National Fuels Meeting of the A. S. M. E.

ous maintenance in the boiler water of definite conditions, as follows:

Whether loss of metal be caused by the pitting of corrosion or general dissolution from contact with water, it is essential that the boiler water contain a slight concentration of hydroxide alkalinity. For assurance of constant maintenance of this condition, a minimum of approximately 50 parts per million of hydroxide (OH) is satisfactory, although the minimum must be higher under certain conditions. It must be subject to careful control, or else it may give rise to trouble from caustic embrittlement and foaming.

For protection of the surfaces from the formation of adherent scale thereon, deposition by the boiler water of calcium sulphate and of calcium or magnesium silicate must be obviated by the continuous maintenance in the boiler water of definite chemical ratios whose values are a function of operating pressure and concentration of certain substances in the boiler water. In general, soda ash may be the conditioning chemical for operating pressures not to exceed 150 to 160 lb.; at higher pressures, its rapid decomposition usually renders impossible simultaneous protection from deposition of scale and caustic embrittlement. Sodium phosphate may be the conditioning chemical at all pressures, low or high.

The "Suggested Rules for Care of Power Boilers," sponsored by the American Society of Mechanical Engineers, defines the relation of sodium sulphate to total alkalinity in the boiler water whose maintenance has never allowed caustic embrittlement to occur.

Surfaces in Contact with Water Below Steam Temperature

Surfaces in contact with water below steam temperature are the surfaces of the heater, feedwater lines, economizer and the preheating section of the boiler. The major problem is corrosion, although prevention of scale formation is troublesome under some conditions.

For the inhibition of corrosion, the maintenance in the water of low oxygen concentration and a pH concentration that shall be not less than about 10, is essential. Whether the degree of oxygen removal shall be that obtained by use of deaerators or deaerating heaters or shall be limited to that possible with a well-vented open heater, must be decided on the basis of various factors. If the open heater is to give fully satisfactory results, sufficient steam must be discharged through the vent to insure low partial pressure of oxygen in contact with the water and the temperature must be maintained at or close to normal boiling temperature.

Certainty of maintenance of a desirable pH concentration is an exceedingly important factor, as hydroxide alkalinity in the contacting water is of great influence in retarding any corrosive action. The rate of flow through the economizer and the preheating section of the boiler is another factor, since sluggish flow is harder to protect against than more rapid flow. In general, the greater the amount of oxygen in the water, so much the more carefully and so much the higher must the hydroxide alkalinity be maintained. Even with the condition of perfectly deaerated distilled water, the pH concentration should not fall below a minimum of approximately 9.6 to avoid slow dissolution of the metal if not actual pitting.

The problem of preventing corrosion would be more simple if protective coatings could be made so effective that the pH concentration of the water making contact with these surfaces could be disregarded. Unfortunately, imperfections in protective coatings are usually discovered, not before they go into service, but by corrosion which has occurred before the boiler is again opened. It seems only reasonable, therefore, whether protective coatings are used or not, to give to the surfaces the protection of water with a desirable pH concentration and with oxygen removed, conditions which can be assured at all times without opening the boiler.

Surfaces in Contact with Water and Condensing Steam

Surfaces in contact with water and condensing steam are the surfaces of steam lines and turbines and the water is that which has its source in condensing steam and not in carry-over of boiler water.

Maintenance of definite alkaline conditions in the boiler water as already stipulated precludes possibility of any acid components in the steam other than carbon dioxide. Thus the main essential for protection of these surfaces from corrosion is the elimination of carbon dioxide and oxygen from the steam, and since in the absence of oxygen, carbon dioxide is far less detrimental than in its presence, the elimination of oxygen is the most important consideration. Elimination of these gases must be effected by conditioning the water before it enters the boiler.

Chemical means for eliminating oxygen seem not to have found favor. Removal of the carbon dioxide, on the other hand, must be accomplished by chemical means. Quality of the steam as regards content of carbon dioxide and oxygen thus harks back to the raw water and the equipment chosen for its processing. The engineer, however, in the full assurance that without regard to processing equipment the maintenance in the boiler water of requisite conditions guarantees him clean surfaces, is free to choose his equipment on the basis of the most economic and satisfactory methods of obtaining those conditions which control corrosion in the economizer and the content of corrosive gases in the steam.

Boiler Water and Steam-Liberating Space

When pure distilled water is boiled, bursting of the bubble film is practically instantaneous. Every molecule of sodium sulphate or chloride or hydroxide or carbonate or phosphate dissolved in the water apparently has an influence in retarding their bursting and thus in stabilizing the films. Addition of particles of suspended material may likewise enhance stabilization, though their effect is more nearly comparable to addition of inorganic soluble substance than to that of a soap.

On the other hand, if a water contains a few parts per million of hydroxide and calcium, a condition characteristic of under-treated waters, the concentration of soluble and suspended solids therein may be very high without largely stabilizing the films of the bursting steam bubbles. Addition of a few parts per million of a tannate induces still better boiling conditions, but is of no value when the calcium is removed.

Again, addition of two or three parts per million of an oil, such as castor or other vegetable oil or such as sperm or other fish oil, can exercise a tremendous influence in lessening stability of the films and inducing in a foaming water conditions which are equal to distilled water boiling. Waxes, the higher alcohols and certain components in the asphalts have a like effect.

These results are obtained only in the absence of appreciable quantities of any soap. In the presence of soap, the only remedy known to the author for suppressing foaming is introduction into the boiling water of relatively small quantities of an inactive and insoluble gas.

None of these methods for quieting foaming is available in practical operation. An undertreated water is undesirable in any case and is an impossibility for the modern generator; hence any aid from the tannates and calcium passes out of the picture. The boiler water must be alkaline; hence any saponifiable oils cannot be used without excessive blowdown. Use of unsaponifiable substances suffers from the troubles of absorption and decomposition of the organic bodies at boiler water temperatures, becoming too costly. It is necessary, therefore, to face the issue squarely on the basis for eliminating undesirable factors in the boiler water where possible and in coördinating maintenance of requisite quality therein with design of steam-liberating space and employment of equipment that effects separation of water from the effluent steam.

In the absence of saponifiable contamination, the permissible concentration is a function of various factors: (*a*) With steady load, a much higher concentration can be tolerated than with variable load. In the latter case, rate of formation of steam bubbles is seldom in equilibrium with rate of disruption; hence the steam space may be insufficient at times of suddenly increasing load for disruption to occur therein and carry-over of boiler water is the result. (*b*) If uniformity of pressure is lacking throughout the boiler, the water level in different drums may be markedly different and result in unsatisfactory steam, or if large differences in concentration of the boiler water exist in different drums, steam from one may be acceptable while that from the other is not good. These are conditions that may be readily eradicated. (*c*) The effluent steam may be dry at low ratings but contain quantities of water at higher ratings even though no taint of bad boiling attaches to the boiler water. Naturally, the answer in this case is more ample provision for mechanical separation of steam and water. (*d*) Type of boiler may have considerable influence.

Thus, within the author's experience, very heavily concentrated boiler waters readily produce dry steam in certain instances while others of the same or less concentration require every precaution for the protection of the steam. In the cases chosen for comparison, the type of boiler is the variable and not contamination or changing load. (e) Baffling of the steam drum, location of steam offtake, and installation of steam separators, internal or external, are other factors of influence in limiting or expanding permissible concentrations in the boiler water.

There is no royal road to dry steam conditions. Even with a large proportion of condensate and evaporated makeup water, present-day high ratings offer a problem in the spray from violently bursting steam bubbles, even if the concentration of the boiler water is not built up, due to condenser leakage.

The fact must be recognized that a fully conditioned water does not boil as smoothly as one not conditioned; absence of calcium in the former is the cause.

Opposed to this, the modern generator requires complete conditioning of the water to insure its desired certainty of continuous operation. That these two conflicting conditions may be met, the steam-liberating space in the boiler must be designed with foreknowledge of water and load conditions on which it is to operate and with clear insight into the fundamental characteristics of boiling water.

Conclusion

In this portrayal of the present status of boiler-water conditioning, mention of new chemicals is conspicuous by its absence. Panaceas existent in sales arguments, proprietary compounds with their numberless mixtures of many types of material, colloidal treatments and arrangements of thermocouples are out of step with the exact demands of present-day water conditioning.

No consideration has been given to the relative mechanical merits of different types of equipment, whether softeners, deaerators, evaporators, or steam separators. These features must be satisfactory, or else the equipment would not survive the keen competition to which it is subjected.

Throughout this discussion, however, the words "maintenance of conditions" have occurred. They constitute the main theme of the systematic and exact water conditioning which is a necessity for modern generators. To make systematic water conditioning a reality, it has been necessary not to introduce new chemicals, not to specify equipment but to define with exactness those relations for the contacting water which protect the surfaces from economizer or heater to turbine. Specific type of equipment for realizing the essential relations is secondary to their maintenance and is a matter of indifference from the standpoint of water conditioning so long as it is sufficiently flexible to permit simple and dependable maintenance.

High-Pressure German Plant Shows Good Efficiency*

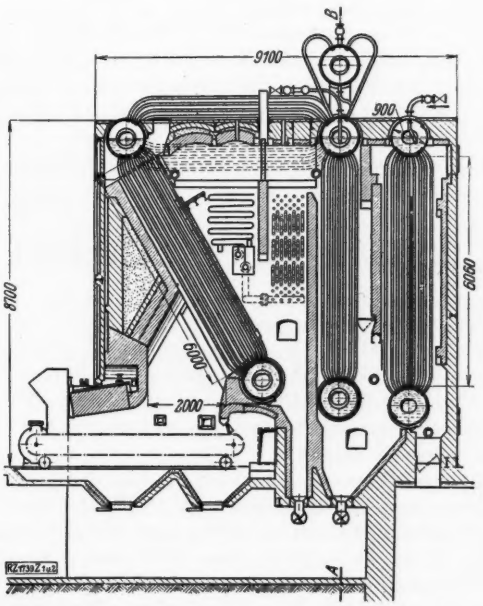
TESTS OF an 875-lb., 800-deg. F. Borsig-Schmidt boiler, one of the first high-pressure installations in Germany were reported in a recent issue of the VDI. The boiler, shown in cross-section, has 3014 sq. ft. heating surface, and a 1464-sq. ft. superheater as well as a 2163-sq. ft. economizer operating under a pressure of 29 lb. The boiler has 1528 sq. ft. in the first pass and 1486 sq. ft. in the second pass. Ordinarily Upper Silesia nut coal with a higher heating value of 12,874 and a lower heating value 12,377 B.t.u. per lb. is burned on the 110-sq. ft. traveling chain grate stoker.

Practically all the steam generated is used in the tandem compound engine operating against a back pressure of 150 lb. The engine is direct connected to a 100-lb. air compressor and the exhaust steam is used in steam hammers. After 2400 hr. of operation, the

*Translated by John H. D. Blanke.

installation was tested by Prof. E. Josse, while burning the coal mentioned above.

During a 6-hr. test at 882 lb. abs., 797 deg. F. and hand firing, the CO_2 averaged 12.8 per cent with a boiler efficiency, based on the lower heating value of the coal of 82.9 per cent. Feedwater ahead of the low-pressure boiler feed pump averaged 80.6 deg. F. and this was increased in the economizer to 206.6 deg. F. as measured at the suction of the high-pressure pump. The heat balance showed 82.9 per cent of the heat in the coal accounted for in the steam, a flue gas loss of 11.4 per cent, an ash pit loss of 2.3 per cent and an unaccounted for loss of 3.4 per cent. Of the 82.9 per cent accounted for in the steam, 7.7 per cent was absorbed in the economizer, 12.9 per cent in the superheater, 54.7 per cent in the first bank and 7.6 per cent in the second bank of the boiler. These figures show that the first bank of tubes absorbed 7 times as much heat as the



CROSS SECTION OF GERMAN BOILER WHICH HAS BEEN OPERATING AT HIGH PRESSURE FOR MANY MONTHS

second bank. The second bank is also expensive to forge and these two facts led to the conclusion that it is better to build the second pass into the economizer and add an air preheater.

During the test, an evaporation of 7.7 lb. of water per sq. ft. of heating surface was obtained, but it is expected that this can be increased, as previous tests have shown an evaporation as high as 7.89 lb. per sq. ft. per hr.

At the same time, a 3-hr. boiler test on the 13.2 and 20.3 by 35.4-in., 166.5-r.p.m. Borsig-Schmidt tandem compound engine was made. An indicated hp. of 832 was developed on about 16.7 lb. of steam per i.hp-hr. The engine received steam at an average pressure of 849 lb. per sq. in. abs., 752 deg. F. and exhausted against a back pressure of 179 lb. absolute to a turbine set over a surface condenser. This corresponds to a Rankine cycle ratio of 91 per cent based on the indicated horsepower developed.

Operation of Auxiliary Steam Turbines

A Few Hints to Operators Which Will Enable Them to Obtain Satisfactory Operation. By Benjamin H. Wood

ALTHOUGH AUXILIARY steam turbines are relatively simple pieces of apparatus, there are several points connected with their operation that are sometimes misunderstood. Among these are the proper manipulation of nozzle control valves and the things to investigate if a turbine will not carry its load.

Most auxiliary steam turbines are equipped with hand valves that shut off or open up extra nozzles. These are furnished for three purposes:

1. To shut off nozzles so as to secure good efficiency at partial loads. This is the most common purpose.

2. To bring additional nozzles into action to enable the turbine to pull full load with reduced steam pressure.

3. To open extra nozzles so that the turbine will carry overload.

A natural question is how can the operator tell the purpose of hand control nozzles on any particular turbine? If the turbine is new, the builder's proposal will, of course, give this data. If, however, the turbine has been installed for some time, it is a different story. The information can still be obtained from the manufacturer, but usually this is not necessary provided the following rule is adhered to: Keep as many nozzle control valves closed as load conditions will allow. This will maintain the pressure in the steam ring as high as possible. Steam will reach the nozzles at full pressure and maximum power will be delivered from a given steam flow. If more nozzles are open than are needed to carry the load, the governor valve will throttle the steam and thereby reduce its pressure. The turbine should never be operated with hand valves "cracked." This has the same effect as throttling in the governor valve proper. Keep them fully open or fully closed. The seats of the valves should be regularly inspected to guard against leaks.

Factors Affecting Turbine Loading

It is occasionally found that a turbine will not carry the load which is placed upon it. This may be due in general to three causes: incorrect plant conditions, excessive load or improper turbine adjustments.

It is somewhat surprising how little importance is attached to correct operating conditions by many engineers. They would not consider connecting a motor designed for 220 v. to a 110-v. circuit. On the other hand, they do not hesitate in many cases to put a turbine built for 200 lb. steam pressure on a 100-lb. line and expect it to operate satisfactorily and to pull full load. For any turbine to run and give good service, it must be used under the conditions for which it was designed. That is, the conditions must correspond with those stamped on the turbine name plate and include steam pressure (at the throttle), superheat, back pressure, speed and horsepower. Unless the actual conditions tally up with these, satisfactory service cannot be

expected. If they are less, the turbine ordinarily will not give its rated output.

If the plant conditions are found correct and the turbine still does not pull the load placed upon it, an investigation should be made as to what power the turbine is actually delivering. It is quite common to find that the machine is overloaded. It should be remembered that driven machines often decrease in efficiency after they have been in service for any length of time. This is especially true of centrifugal pumps that operate under severe conditions.

Measuring the Output

It is a comparatively easy matter to measure the output if the unit is a turbine-generator, but when the turbine is used for pump or fan drive, it is somewhat difficult. Under the latter conditions, the following readings can be taken and forwarded to the turbine manufacturer with the request that the horsepower be computed. The manufacturer, with the aid of well-accepted formulas and the record of the nozzles in the machine, can easily compute the output.

The readings to be taken are:

1. Steam pressure at the turbine.
2. Steam pressure in the turbine steam ring.
3. Revolutions per minute of the turbine.
4. Back pressure at the turbine exhaust.
5. Number and location of hand control nozzles, open or closed.
6. Superheat or moisture in the steam.

At least four sets of readings should be made to secure accuracy and the pressure gages should be calibrated before the runs. Be sure to note down the serial number of the turbine for the information of the builder.

As regards improper turbine adjustments, it is rather difficult to discuss them in a general way since turbine designs vary. In general, the following points should be noted. Any adjustments that are made should be carried out in accordance with the manufacturer's printed instructions.

1. Governor valve opening. This may not be sufficient. Care should be used in adjusting it. Too much valve opening might cause overspeeding.
2. Axial position of the rotor.
3. Condition of the strainer in the steam line.
4. The governor may be set low so that it closes the governor valve before the turbine comes up to speed.
5. Condition of nozzles. One or more of them may be stopped up.
6. Worn parts, such as buckets and nozzles.

Superchargers Used in Odessa Diesel Station

Motor Driven Blowers Supplying Air to Engines Features of Texas Electric Service Co. 2850-Kw. Plant

ELECTRIC POWER demands in West Texas have been increasing at a phenomenal rate since the extensive development of the many oil fields in that territory has been under way. In the fall of 1927, the load of the Western Division of the Texas Electric Service Co. properties was around 5000 kw-hr. for the maximum hour of the month with a load factor of about 65 per cent. In February, 1928, this had increased to over 8000 kw., in April to 12,500 and in June to 16,320. During the same period, the monthly load factor increased until it now ranges from 70 to 75 per cent, the highest value shown by records being 82 per cent. All of the preceding figures are based on the maximum hour for the month.

This company is affiliated with the Texas Power & Light Co. and the Western Division extends approximately 200 miles in a general east and west direction along the Texas & Pacific Railroad from Eskota to Pyote, Texas, taking in the larger towns of Sweetwater, Big Spring, Midland and Odessa. The system is connected with, and obtains most of its power from, the Leon generating station located near Eastland in the Eastern Division of the Texas Electric Service Co., the two divisions being connected between Eastland and Eskota through lines of the West Texas Utilities Co.

The Eastern Division of the Texas Electric Service Co. is interconnected with the system of the Texas Power and Light Co. so that all of the capacity of this system, including the Trinidad Station of the latter company, is available to the West Texas properties. An interconnection agreement has been made whereby the Texas Electric Service Co. sells power to the West Texas Utilities Co. at the Leon station and in turn buys from the West Texas Utilities Co. at Eskota. Energy is also interchanged between these two companies at Crane, south of Odessa.

Although there are a number of generating stations along the line, the only one west of Eskota, used for other than standby service, is the new Diesel station at Odessa. From Odessa there is a 60-kv. loop line out to the Winkler oil field and other down through Crane and the Chalk oil field back to Big Spring. They are also interconnected with the Insull properties in a larger loop from Crane through McCamey, San Angelo, Ballinger and back to Abilene on the Leon-Eskota line.

Diesel Station Installed to Handle Rapidly Growing Load

At the time this oil field load began to develop, there was one 60-kv. line from the Leon plant to Eskota and a 33-kv. line from Eskota to Big Spring, Midland and Odessa being served by a 500-kw. plant at Midland.

Because of the time necessary to build the 132-kv. line from Leon to Big Spring and the 60-kv. lines from Big Spring west, with necessary substations, it became necessary to install generating capacity at Odessa to take care of this oil field load temporarily. On investigation, it was found that this capacity could be made available most quickly by moving three 500-hp. engines from the Paris generating station of the Texas Power and Light Co. where they were no longer needed and purchasing two 1250-hp. engines which could be obtained for almost immediate delivery from the manufacturers.

These five engines were, therefore, installed at Odessa to take care of the load temporarily and later to be available as standby for emergency operation and to furnish necessary kilovolt-ampere capacity for relaying in case of line trouble. At the present time, the load on this system has grown to such an extent that the system is almost entirely dependent on the steam generating capacity of the central system through the 132 and 60-kv. lines feeding west from the Leon station.

Ultimate Capacity Not Yet Reached

In the plan of the Odessa Station, Fig. 1, the arrangement of the engines and other equipment is shown. At present, the installed capacity is 2850 kw. made up of five main units numbered as shown in the drawing. Engines No. 1, 2 and 3 are McIntosh-Seymour 500-hp., 164-r.p.m., 4-cycle, air injection units direct connected to General Electric type AT1, 350-kw., 0.8-p.f., 2300-v., 3-phase, 60-cycle generators. Each of the three engines is arranged for a belted exciter, although at present only engine No. 1 has the exciter instaled; this is known as Exciter No. 1, a General Electric Class 4, Form H, 110-v. d.c., 320-amp. 605-r.p.m. machine. Engines No. 1 and No. 2 were put in service June 29 and No. 3 on July 6, 1927.

Engines No. 4 and 5, put in service on February 8 and February 23, 1928, respectively, are Nordberg 1250-hp., 180-r.p.m. type 5 EG 2-cycle, air injection engines direct connected to General Electric Type AT1, Form E, 900-kw., 0.8-p.f., 2300-v., 3-phase, 60-cycle generators. The station is not yet completed to its ultimate capacity and the building, switchyard and water facilities are designed to permit the addition of two 900-kw. or larger units.

In addition to the five main generating units, a Lombard 120-hp., 360-r.p.m. engine direct connected to a General Electric Type T.R.E. 100-kw., 0.8-p.f., 2300-v., 3-phase, 60-cycle generator and a General Electric 5-kw., 125-v. d.c., 40-amp. exciter, is installed as a house generator. This unit is connected directly to the 2400-v., auxiliary bus No. 2, as shown in the single line diagram, Fig. 4, and is used to carry the more important auxiliary load.

Spur Track Extends Into Building

Of steel construction, covered with corrugated iron, the building, Fig. 2A, is designed so that it can be extended two ways; to the east, for the installation of two 5000-kv.a. synchronous condensers and to the west, for the installation of additional generating units. As shown by dotted lines in Fig. 1, space has been left in the yard for an additional cooling tower.

At the east end of the building, a rolling door has been provided and a spur track extended into the building so that a car can be run inside and unloaded direct by the 10-t. Chisholm-Moore crane which runs the entire length of the building. This track comes between the 120-hp. Lombard engine, Fig. 2K, and the three stage, 10 by 6½ by 3 by 12-in., 1100-lb. Ingersoll-Rand auxiliary air compressor, Fig. 2H, close belted to a 75-hp., 900-r.p.m., 2200-v. General Electric motor.

Auxiliary equipment is arranged along the two sides as shown in Fig. 1. At the north side is the switchboard with the three motor driven exciters, No. 2, 3 and 4 arranged compactly at one end. Exciter No. 2 is a 100-kw., compound-wound, 125-v., d.c., 1200-r.p.m. generator driven by a 150-hp., 220-v. General Electric induction motor, while No. 3 and 4 are 35 kw., 125-v., d.c., 1200-r.p.m. General Electric generators driven by 220-v. induction motors. Space has been provided for an additional unit.

The south bay is utilized for the machine shop, Fig. 21, and the store room. Oil and water pumps, supercharger fans, air washers and water treaters are arranged along the south side in the basement as shown in Fig. 3, a section through the building.

In Case of Trouble Station Lights Are Carried on Storage Batteries

This section also shows the battery room located under the exciters. This battery is a 50-cell Exide charged by a General Electric 1¼-kw., 140-v., 1800-r.p.m. battery charger. In case of electrical trouble the lights are automatically switched over to the battery

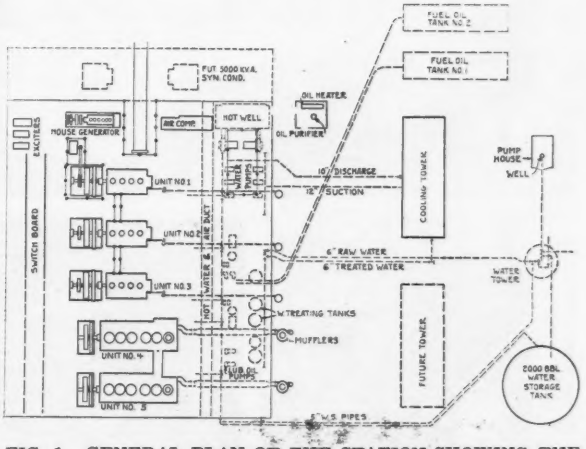


FIG. 1. GENERAL PLAN OF THE STATION SHOWING THE LOCATION OF THE FUEL OIL AND WATER STORAGE FACILITIES.

unit, to prevent the possibility of the station being in darkness even during the most severe trouble.

Fuel oil received by tank car is delivered by a Los Angeles valveless pump to the 20,000-bbl. storage tank south of the main power plant building, and may be unloaded by gravity into either of two 20,000-gal. underground tanks located east of the cooling tower. The vent from No. 1 underground tank is visible between the two exhaust mufflers in Fig. 2-E. Oil from the 20,000-bbl. storage tank is pumped through a Braun oil heater to a DeLaval No. 900 centrifuge from which it flows by gravity to either of the two 20,000-gal. underground storage tanks. From the underground storage tanks, the oil is pumped to the 200-gal. overhead fuel oil tanks, shown in Fig. 3, by one of the two Blackmer No. 3 rotary pumps driven by General Electric Co. 1-hp., 1800-r.p.m., 220-v. motors. Overflow from these tanks is collected in an overflow header which drains back to No. 1 storage tank through a 2-inch line.

Lubricating oil is circulated by four Blackmer No. 2 rotary pumps driven by General Electric ¾-hp., 1800-r.p.m., 220-v. motors. Engines No. 1, 2 and 3 are served by two pumps with a Bowser 200-g.p.h. oil filter and 3-bbl. oil storage reservoir. Engines No. 4 and 5 are

served by similar equipment. The oil storage tank and two of the lubricating oil pumps are shown in Fig. 2L with the two fuel oil pumps in the background.

Both of these lubricating oil outfits are hooked up so that the oil from either can be run through a single DeLaval No. 900 centrifugal purifier belted to a 5-hp., 1750-r.p.m., 220-v. Westinghouse motor. This purifier is started up at noon and midnight each day. Oil

1800-r.p.m., 220-v. motor, pumps the water to an overhead tower of 12,000 gal. capacity. The pump house, storage tank, and tower are shown in Fig. 2F.

As this water is quite hard, about 17 gs. per gal., it is treated by a Permutit water softener rated at 9000-gal. in 6 hr. This treated water is used as makeup to the cooling tower.

Cooling water for the jackets is handled by two sets

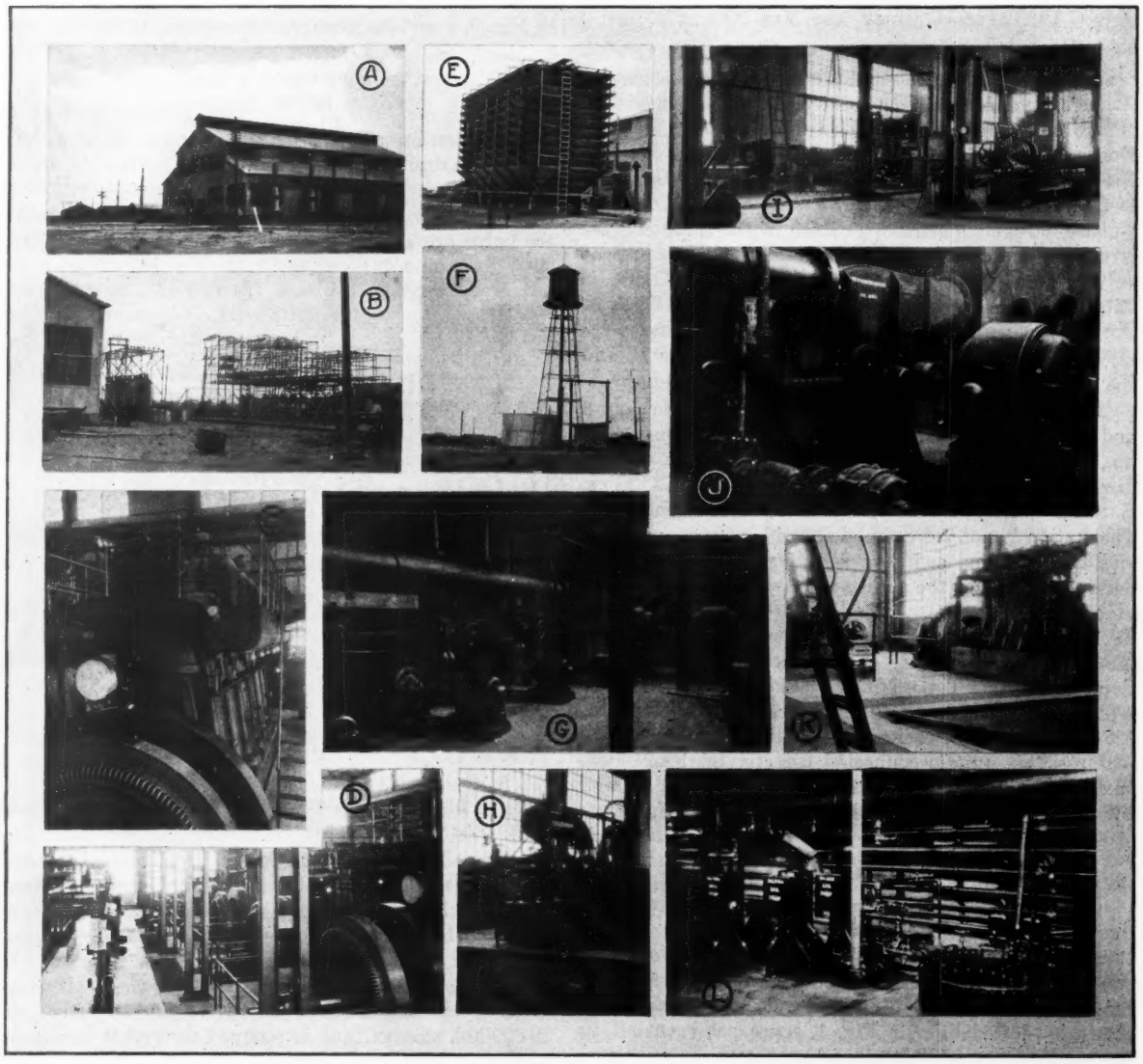


FIG. 2. VIEWS OF THE INTERIOR AND EXTERIOR. A—POWER PLANT BUILDING. B—TRANSFORMERS AND SWITCH-YARD. C—ENGINE NO. 5. D—GENERAL VIEW OF THE ENGINE ROOM. E—COOLING TOWER. F—WATER STORAGE TANKS. G—WARM WATER PUMPS. H—AUXILIARY HIGH PRESSURE COMPRESSOR. I—MACHINE SHOP. J—MOTOR DRIVEN SUPERCHARGER. K—AUXILIARY GENERATING UNIT. L—FUEL AND LUBRICATING OIL PUMPS

returns by gravity from the engines and flows through the filter to the storage tank from which it is picked up by the float controlled pump and elevated to the tanks above the engines.

Water for the engines and general service around the plant is pumped from deep wells and stored in an 80,000-gal. ground storage tank. From the ground storage tank, a float controlled 400-g.p.m., 80-ft. head Goulds pump driven by a General Electric 7½-hp., of pumps, some of which are shown in Fig. 2G; three 500-g.p.m., 80-ft. head, Worthington, single stage centrifugals driven by General Electric 15-hp., 1800-r.p.m., 220-v. motors, pumping cold water from the tower to the engines and four 250-g.p.m., 63-ft. head, Worthington centrifugals driven by General Electric 10-hp., 1800-r.p.m., 220-v. motors, pumping the warm water from the engines to the cooling tower. Cold water for all engines is taken from a common header,

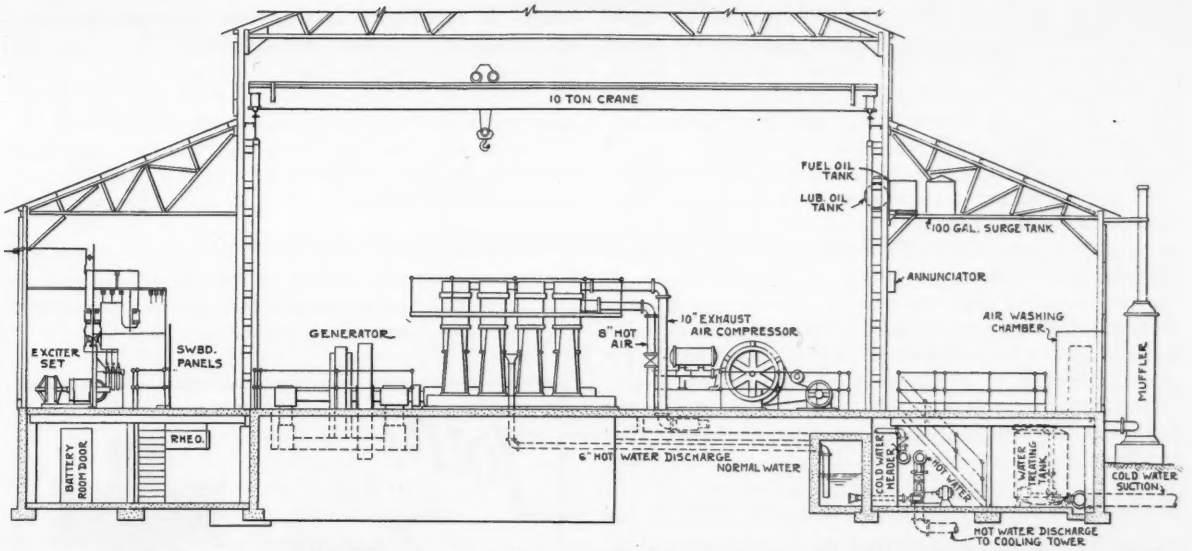


FIG. 3. TRANSVERSE SECTION OF THE ODESSA STATION. THIS IS SECTION FIG. 1, TAKEN BETWEEN UNITS NOS. 1 AND 2

while warm water from the engines collects in a tunnel which runs the entire length of the building and from which all four pumps take their suction. In case of failure of the water supply pumps, a valve automatically admits raw water from the tower to the engines. The cooling tower is shown in Fig. 2E.

All of the exhaust lines from the engines to building wall are water cooled and water for this purpose is circulated by an Allis-Chalmers 350-g.p.m., 35-ft. head, single stage centrifugal driven by a 5-hp., 1800-r.p.m., 220-v. motor. An elevated tank shown in Fig. 3 serves as a surge tank for this system.

Supercharging Increases Maximum Load

Air for supercharging is supplied by two Sturtevant Size 7 blowers driven by General Electric 100-hp., 1800-r.p.m., 2300-v. motors, shown in Fig. 2J. The function of the superchargers is to compensate for the loss of capacity in the engines due to the elevation above sea level. The supercharging air is washed in spray type washers and delivered at the top part of the tunnel into which the hot water from the engines drain. This insures saturated air at an almost constant temperature.

Failure of the lubricating oil supply to the individual engines, low levels in the overhead lubricating oil tanks, low water in the elevated storage tank or low pressure in the cold water supply header are indicated automatically on a 16-point annunciator located about midway of the engine room where it is visible and audible both to the operators and the repair men working in the machine shop.

At present, the electrical switching and control is

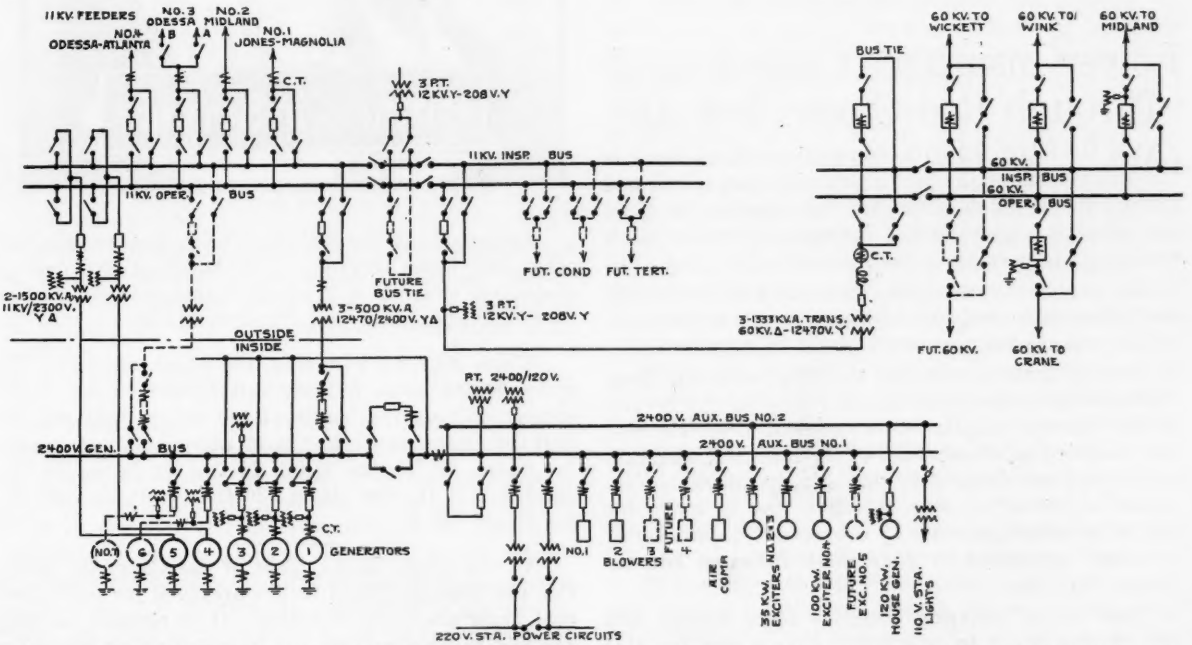


FIG. 4. THREE ENGINES ARE SERVED BY A SINGLE TRANSFORMER BANK WHILE TWO ENGINES HAVE INDIVIDUAL THREE-PHASE TRANSFORMERS

handled by 25 black slate panels arranged in three groups with electrical connections as shown in the single line diagram, Fig. 4. Two 2400-v. auxiliary buses, located at the east end of the switchboard, are provided with a suitable tie between them and the 2400-v. generator bus. Eventually the 220-v. auxiliaries, one of the exciters and the station lights will be carried on the house generator. All auxiliaries are supplied from an auxiliary bus connected by circuit breaker to the main 2400-v. bus. The 350-kw. units are so arranged that they can be connected either to the main bus or to the auxiliary bus and it is practice to keep one of these units always connected to the auxiliary bus, its capacity being ample to take care of all auxiliaries. The bus tie circuit breaker is provided with under-voltage and under-frequency relays which open the circuit breaker in case of transmission line disturbance, thus protecting auxiliary service.

Station Connected with Both 11- and 60-Kv. Lines

Engines No. 1, 2 and 3 are connected through the 2400-v. bus to the low side of three 500-kv-a., single-phase transformers connected 2400-v. delta to 12,470 v. Y. Engines No. 4 and 5 each have their own 1500-kv-a., 3-phase transformers connected 2300-v. delta to 11-kv. Y. with all switching done on the high-tension side. The switchyard and transformers are shown in Fig. 2B.

As this station operates in parallel with both 11 and 60-kv. lines, two high-tension bus systems are provided, both of them being in duplicate, that is an operating and inspection bus, so that inspection and repairs will cause no interruption of service. These two systems are connected through three, 1333-kv-a. transformers delta-Y connected as before. All generating units are tied into the 11-kv. bus and in case of serious line disturbances the station and 11-kv. system are cut loose from the 60-kv. system, leaving the engines to carry the load on the four 11-kv. feeders.

Lower Insurance Costs Sought Through Red Cross First Aid

ONE OF THE MAJOR industrial problems today is curtailment of the loss from accident in plants and manufacturing establishments. This problem is given still another aspect by the increasing trend towards workmen's compensation insurance.

Six per cent of all deaths annually are due to accident, though the majority of these are due to the automobile and are not necessarily in the industrial field.

Largely aimed at reducing the toll of accidents, from whatever cause, the First Aid and Life Saving Service of the Chicago Chapter, American Red Cross the past year enrolled representatives of 25 industrial establishments in classes fostered by the casualty insurance companies of the city. One objective was to lower the cost of casualty insurance by decreasing the number of accidents aggravated by preventable infection and improper handling.

This idea of lowering insurance costs through first aid training is not an experiment, having been initiated earlier through efforts of the Hartford Insurance Company. At that time, students from 25 companies carrying casualty insurance were enrolled for First Aid training. The results obtained by one company alone, one year after completion of the course, had shown such improvement as to pay for the entire experiment.

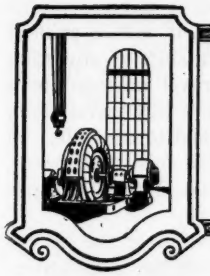
In Chicago, the Red Cross Chapter there expects to have 600 students complete the course during the year, as a result of coöperative effort by industries and insurance companies.

First Aid instruction is a part of the permanent Red Cross program, carried on among schools, colleges, industries, utilities, power plants, engineering companies and a host of other widely varied groups.

Membership in the Red Cross helps support this and other Red Cross services. Enrollment of five million Red Cross members will be asked this year during the Twelfth Annual Roll Call, November 11-29.

When splicing wire rope, the length needed in the splice should be as follows, half from each end to be spliced, so that the length of the splice itself will be half the figure given: For ⅜-in. and ½-in. rope, 15 ft.; for ⅝-in., 20 ft.; for ¾-in., 24 ft.; for ⅞-in., 28 ft.; for 1 in., 32 ft.; for 1⅛-in., 36 ft.; for 1¼-in., 40 ft.; for 1½-in., 45 ft.

At the Flint, Mich., plant of the Chevrolet Motor Co., two 1000-hp. Heine boilers arranged for pulverized coal firing are being installed. It is planned to have the first boiler completed and in operation by November 15 and the second one about the first of the year.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Electricity---What It Is and How It Acts*

PART XII. NATURE OF THE ELECTRIC FIELD. EFFECT OF MOTION OF THE CHARGE UPON FIELD. PRODUCTION OF THE MAGNETIC FIELD

IT IS SOMEWHAT of an anomaly that today, in view of our great advances in scientific knowledge, we are less able to explain the absolute nature of the "electric field" than we were twenty-five years ago. This is due in a great measure to the baffling mystery of space.

Twenty-five years ago, most scientists were pretty well reconciled to the idea of the existence of an ether—not the kind of ether used as an anesthetic but the intangible, imponderable medium which was supposed to pervade all space. Purely an hypothesis, the idea of an ether proved so useful, so satisfied the requirements of innumerable physical phenomena, that today, when as a consequence of the Einstein theory and the quantum theory it is no longer essential, it is very difficult to conceive of a space devoid of it. As a vehicle for the transmission of light and as a medium in which to

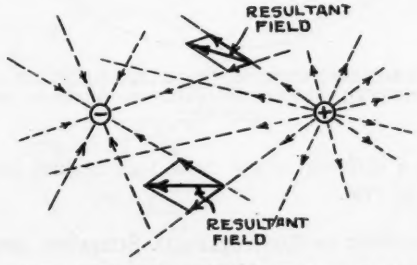


FIG. 1. THE ELECTRIC FIELD AT ANY POINT IS THE VECTOR RESULTANT OF THE SEPARATE FIELDS PRODUCED BY THE TWO CHARGES

imagine an electric or magnetic field, the conception of an ether is invaluable and while it may be possible that no such medium as an ether exists, it is difficult to explain light and other radiation phenomena without it.

ELECTRIC FIELD THEORY OF THE ETHER

In explaining an electric field, it is obviously necessary to conceive of something in the space surrounding the charge producing the field. Whether we think of the field as a distortion or strain in the space medium itself or consider the space medium to be something emanating from the charge, the result is the same—something in the space is different in the presence of a charge than it is without it. According to one theory, which has much to recommend it, the ether is considered as being the combination of the individual fields of all the electric charges in the universe.[1] Thus, in Fig. 1, a negative and positive charge are shown close together;

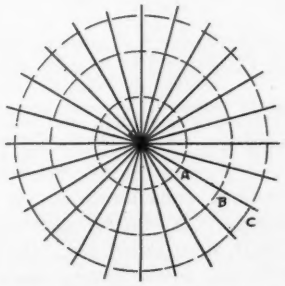


FIG. 2. REPRESENTATION OF THE ELECTROSTATIC FIELD SURROUNDING A STATIONARY ELECTRON

The dotted lines A, B, and C, represent the equipotential surfaces. This diagram must be regarded as a cross section through a sphere, for the lines of force around the charge extend outward, radially in all directions.

the electric field of each, individually, has a radial distribution as indicated by the dotted lines. At any point in space, the actual electric field so far as these two charges are concerned, is obtained by combining vectorially, the two separate radial fields. The actual field is thus constructed at several points as in Fig. 1. In a similar manner, all other charges in the universe could be cared for and so the actual field at any point in space determined. Most of the phenomena such as radio waves, propagation of light, etc., which require for their explanation an ether with impossible properties, can be reasonably well pictured if we consider the ether as the superimposed electric fields of all the electric charges in the universe.

While this concept is useful in explaining certain phenomena, it by no means explains the nature of the electric field nor of the ether. To the average reader, however, who needs something to visualize, it is well worth while and in the following discussion of the electromagnetic field we will keep it in mind. Regardless of how broad minded we may be, we must think of the lines of force as being made up of something.

As was shown in a previous article,[2] the electric field surrounding a stationary charge, say an electron, may be represented by straight lines of force drawn radially

*All rights reserved.

[1] Morecroft, Principles of Radio Communication, p. 6.

[2] Part V, July 15 issue, p. 778.

outward from the center of the charge. The direction of these lines of force, everywhere, represents the direction of the field and the number of lines per square centimeter or square inch represents the strength of the field. These lines of force must be considered as permanently attached to the charge like so many stretched rubber bands. In fact, whether the electron actually consists of a small charge located at O, Fig. 2, or whether the modification of the ether or space itself constitutes the electron is an unanswered question, but

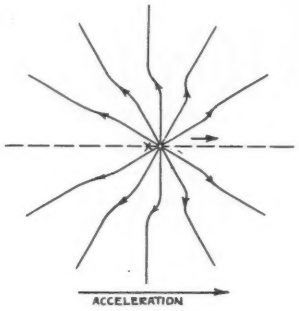


FIG. 3. THE DISTORTED FIELD ABOUT AN ELECTRON AN INSTANT AFTER IT HAS BEEN SET IN MOTION TOWARD THE RIGHT

Since the lines of force are thought of as non-rigid lines attached to the charge, it is evident that when the charge is suddenly set in motion, the movement of the lines of force will lag behind that of the charge. See Fig. 4.

so far as theoretical considerations are concerned it makes no difference. It can be shown that a charge which is uniformly distributed over the surfaces of a sphere acts as if the whole charge were concentrated at the center of the sphere.

Effect of Motion of Electric Charge Upon Distribution of Field

Suppose, now, that the stationary electron depicted in Fig. 2 is suddenly set in motion at a uniform speed

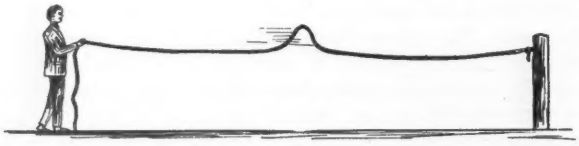


FIG. 4. WHEN ONE END OF A ROPE IS SUDDENLY JERKED IN THIS MANNER, A WAVE WILL TRAVEL TO THE OTHER END

along a straight line toward the right; let us examine the state of affairs at a subsequent instant. It is obvious that at some places sufficiently remote from the charge, the field will be unaware of the alteration that has just been made in the charge's motion and that the lines of force at those places will still be pointed toward the point where the charge was before it was set in motion. It is also evident that there are some points so near the electron that the field has completely adjusted itself to the new condition and here the lines will point directly to the actual position of the charge. From this, it follows that at some points intervening between the two regions, the lines will be bent, as shown in Fig. 3. In other words, the field surrounding an accelerating electron is no longer completely radial to the electron as is the case when it is stationary.

If the electron, which has been set in motion, is permitted to move at a uniform velocity, it will be evident that the point where the "bend" or shift in direction of the lines of force occurs will travel outward in a manner similar to that in which a wave will travel along a rope when one end is suddenly jerked to one side. In the case of the field, the speed at which this wave moves, is the same as the velocity of light, i.e., 186,000 mi. per sec.

This time lag in the effect of motion of the charge to be communicated to the electric field has many interesting consequences and we shall have occasion to refer to it again in connection with other matters concerning the electron but, for the present, it will only be necessary to remember that the field around a moving elec-

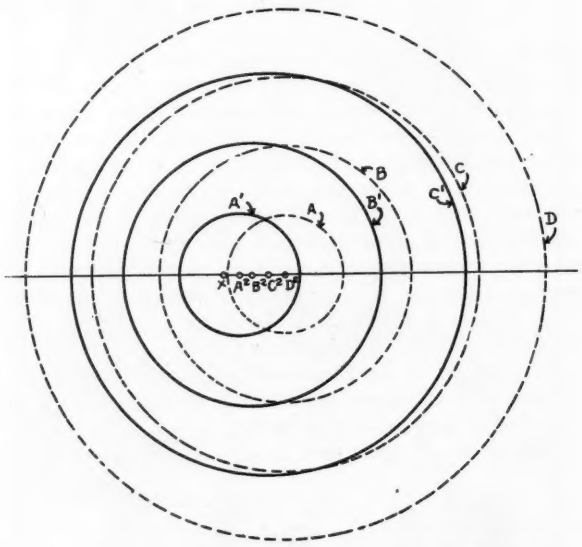


FIG. 5. DIAGRAM SHOWING THE DISPLACEMENT OF THE EQUIPOTENTIAL SURFACES DUE TO MOTION OF THE CHARGE

tron has a different shape from that around the same electron at rest.

Distribution of Equipotential Surfaces Around Charge

Before we proceed with an explanation of a magnetic field, however, it will be well to show what is meant by the equipotential surfaces around a charge. Referring to Fig. 2, it will be noted that in addition to the radial lines of force, a number of concentric circles are drawn around the charge. These circles, in reality spheres, for the diagram must be regarded as a cross section through a sphere, are circles or surfaces of equal potential because all points along the circumference (or on the surface of a sphere) are the same distance from the center. For this reason, they are called equipotential circles or surfaces as the case may be.

Suppose again, as in the previous case, that the charge at the center is suddenly set in motion. The electric field immediately surrounding the electron will tend to move with the electron and as a consequence, the equipotential surfaces in that portion of the field will be shifted in the direction of motion of the charge. Thus the equipotential surfaces will no longer be con-

centric. The effect is illustrated in Fig. 5 in which the dotted circles A, B, C and D are the equipotential surfaces of a stationary charge at D_2. The solid circles A^1, B^1, C^1 and D are the same equipotential surfaces shown by the dotted circles but represent their position

FIG. 6. THE EFFECT OF MOTION OF A CHARGE IS TRANSMITTED TO DISTANT PARTS OF THE FIELD SIMILAR TO THE MANNER IN WHICH THE MOTION OF THE ENGINE IS TRANSMITTED TO THE CARS IN THIS DIAGRAM

for the moving electron during the time it has moved along the line M-N from D_2 to X. The circle A^1 is the equipotential circle A and its position is still the same as though the electron were still at A_2. In other words, this circle is not yet aware of the fact that the electron has moved from A_2 to X. Similarly, the circle B^1 is not yet aware of the fact that the electron has moved from B_2.

Mechanical Analogy Illustrating Effect of Motion on Electric Field

The effect is very much the same as that which occurs in starting a train of cars which are coupled together by elastic bands or springs as shown in Fig. 6. The instant the engine starts to move, the spring be-

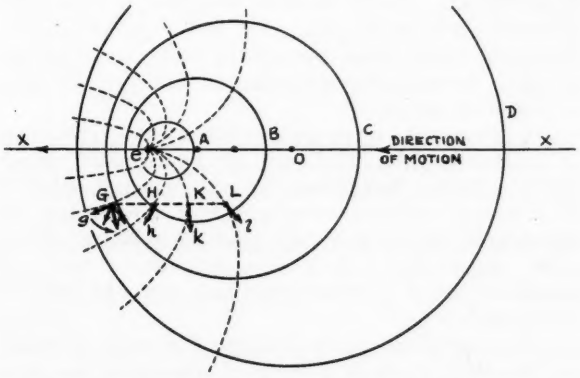


FIG. 7. REPRESENTATION OF THE FIELD AROUND A MOVING CHARGE

tween it and the first car is stretched until the pull is sufficient to move the first car; this starts and stretches the spring between it and the second car until the third car starts. In this way the cars begin to move successively until finally the last car begins to move. The relative position between the cars will then be maintained a constant if the speed of the train remains uniform.

With this picture clearly in mind, it will be possible to show that the lines of force of the electrostatic field around a moving electron at any instant are curved as shown in Fig. 7. Here the direction of the field is obtained by drawing lines of force, through the center charge and normal to all equipotential surfaces at the points of intersection.

Production of Magnetic Field

This change in shape of the electrostatic field, due to the motion of the charge, leads to some extremely important consequence. Referring again to Fig. 7, let us consider a point G, fixed in space and located outside of the line X-X. With the moving charge in the position shown, the field at point G will have a direction Gg, tangent to the line of force passing through the point G at that particular instant. As the electron moves along the line X-X toward the left, different lines of force will pass through G. Thus, where the charge e has moved along XX over total distances equal to GH, GK, GL, the field at G will successively assume directions parallel to Hh, Kk, Ll.

It is evident, then, that as the electron moves along the line XX, the field at a fixed point in space G, will be along a straight line passing through G contained in the plane of the paper and gradually rotating around

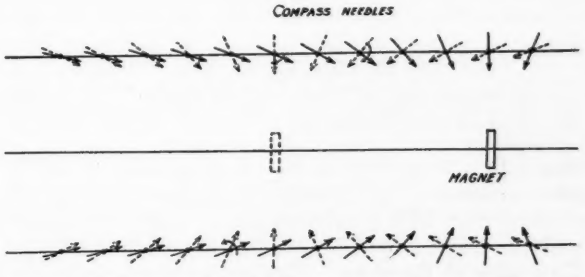


FIG. 8. SIMPLE MECHANICAL-MAGNETIC ARRANGEMENT TO ILLUSTRATE PRODUCTION OF ROTATIONAL STRAIN

In this arrangement a number of compass needles are pivoted along two parallel lines, as shown, while a small permanent magnet is arranged to move horizontally between them. The compass needles represent the lines of force; the magnet the electric charge. When the magnet is moved, the needles will slowly rotate about their axes.

that point. In addition to the radial strain in the space medium due to the presence of the electron, a torsional or rotational strain is set up. This torsional strain in the space medium occurs along a line perpendicular to the direction of motion of the electric charge setting up the field and perpendicular also to the directions of the electrostatic field at the point considered. This force is called an *electromagnetic* force.

This conception may, perhaps, be made a little more clear if we compare it to the arrangement shown in Fig. 8. This diagram shows a small bar magnet arranged between two rows of magnetic needles, pivoted so as to rotate freely. The needles represent the lines of force of an electric field and the bar magnet an electric charge. With the magnet in the position shown, the needles will be attracted to it and will arrange themselves along lines connecting their centers and the bar magnet. If, now, the magnet is moved along the line AB in the direction of B, the needles will gradually be rotated about their axes. When the magnet is at the center as shown by the dotted rectangle, the needles will have assumed positions indicated by the dotted needles.

This is, of course, a crude comparison but it will at least indicate how a horizontal motion of a charge is capable of producing a rotational movement of the lines of force constituting the field.

The picture presented by the magnetic needles and

also by the explanation of the rotating field itself is only half complete. In both cases, we indicated the rotation of only those elements in the plane of the paper. Since the lines of force shown for one plane, Fig. 7, exist identically for all planes containing the lines XX, the electrostatic and electromagnetic fields for the point G will have the same values respectively for all points of the circle described by point G, when Fig. 7 is rotated about the line XX. In other words, the picture presented by the needles in the above analogy would be more accurate if the needles were pivoted along the circumference of a number of rings, as shown in Fig. 9 and the magnet moved along a straight line through the center of the rings. This arrangement, while virtually the same as that shown in Fig. 8, gives a picture in three dimensions.

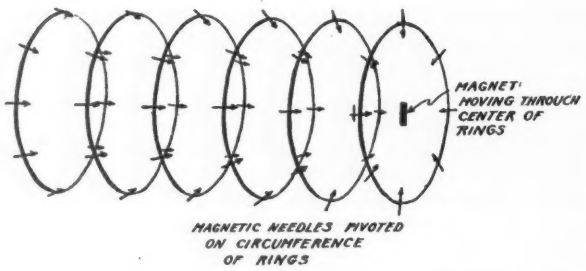


FIG. 9. A MORE CORRECT METHOD OF SHOWING PRODUCTION OF THE ROTATIONAL STRAIN

This arrangement is similar to that of Fig. 8 but in this case the needles are pivoted on a number of loops. This shows the action in three dimensions.

In Fig. 8 is shown a single magnetic loop, due to motion of the electric charge e. In this diagram f is the direction of the electrostatic field. The gradual rotation of this line f about the circular axes g produces a torsional strain along the circle g which is the electromagnetic force. It will be noted that the direction of the electromagnetic force at each point of the circle will be tangent to the circle.

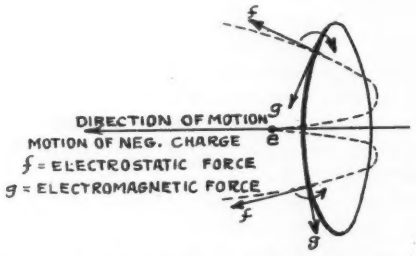


FIG. 10. A SINGLE LOOP OF MAGNETIC FIELD

The curved line f is the line of electrostatic force due to the moving charge e. As the charge moves the line f is rotated about the axes g, causing a torsional strain along g. The direction of g, which is the direction of the magnetic field, is tangent to the circle at any point.

From the foregoing explanation, it will be evident that the magnitude of this electromagnetic strain depends both on the value of the electrostatic field and on the rate at which its direction is turning around the point considered. It, therefore, depends, for a given point in the field, on the value of the moving charge, on its speed of motion and on the shape of its trajectory. If the direction of motion of the charge reverses, the direction of rotation and also the direction of torsional strain will be reversed.

In another article, we shall endeavor to show how this theory of electromagnetic force ties in with the known laws of the electric current and we shall also discuss the forces involved during the motion of an electric charge. This part of this series may seem rather tedious and unduly detailed but it is of tremendous importance and from this standpoint a detailed treatment is justified.

In the meantime, it is reassuring to know that our electron still serves us faithfully in our tortuous journey through electrical phenomena. So far, all physical, chemical and electrical phenomena that we have encountered has been explainable in terms of its properties and if this were a mathematical treatment instead of a purely descriptive work, it would be found that even more perfect conformity would obtain.

Insulating High Tension Cable Joints

By W. E. Warner

SOME EXCELLENT results have been obtained recently in Europe in the use of a new method of insulating high tension cable joints known as the Hochstadter method. After the joint has been made, it is carefully filed smooth to remove any sharp edges and cleaned of any grit; this is necessary, as a sharp edge or point might lead to a brush discharge which would gradually char the insulation and finally cause a breakdown. Every trace of moisture is rigorously excluded, even to the extent of choosing the jointers from men whose hands perspire the least when working, as this is not an infrequent although unsuspected source of defective insulation.

In the case of a 3-phase, 33,000-v. cable, each core is insulated with 130 layers of impregnated paper 0.005 in. thick. Before each layer is put on, it is boiled in a special resinous compound at a temperature of 240 deg. F., to boil away any trace of moisture. After these paper layers have been put on, a strip of metallized paper is wound over each core, the metallic side outside.

This metallized paper consists of a strip of paper on one side of which a layer of aluminum has been electrically deposited. The paper acts as a condenser and also effectively grounds each of the three cores in the event of a breakdown. It reduces the sheath losses and causes the electrical strain on the paper dielectric to be at right angles to the surface. If this metallized paper were not employed, the electrical stress would be tangential at some points, and tangential stresses are much more likely to cause breakdown than radial stresses.

Above this metallized paper are wound some copper and aluminum tape separators to keep the cores apart, and then the whole joint is plumbed into a lead sheath. A cast-iron box is fitted round this to give additional protection. The lead sheath of the cable and the steel armoring wires are secured at the cast-iron box, and in some cases a concrete coffin is placed round it to give additional protection. One of these joints takes two men some 70 hr. to make.

Power Cost Studies in a Printing Plant

FURTHER DISCUSSION AND APPLICATION OF PRINCIPLES OUTLINED IN A PREVIOUS ARTICLE DEALING WITH THE STEEL INDUSTRY. BY OTTOMAR H. HENSCHEL*

IN THE SEPTEMBER 15 issue, we discussed methods of reducing purchased power costs in a steel plant.[1] Let us now take under consideration an industry far different from the steel manufacturing line, namely, the printing and lithographic art and cite the case of a typical medium sized institution. In this installation, the power load at present consists of approximately 185 connected horsepower (units ranging in size from 1/8 to 20 hp.), a heating load of a little in excess of 25 kw. and the necessary plant and office lighting. The consumptions and costs of electric energy for all purposes from January, 1927, to February, 1928, inclusive, were as follows:

Month	Consumption	Net Cost
January, 1927	18,160 kw-hr.	$510.53
February, 1927	15,280 kw-hr.	436.05
March, 1927	15,840 kw-hr.	450.53
April, 1927	15,120 kw-hr.	431.91
May, 1927	15,040 kw-hr.	429.84
June, 1927	17,040 kw-hr.	481.57
July, 1927	18,720 kw-hr.	525.02
August, 1927	17,680 kw-hr.	498.12
September, 1927	16,480 kw-hr.	467.08
October, 1927	17,520 kw-hr.	493.98
November, 1927	17,600 kw-hr.	496.05
December, 1927	20,160 kw-hr.	562.26
January, 1928	16,640 kw-hr.	471.22
February, 1928	18,400 kw-hr.	516.74
Total	239,680 kw-hr.	$6,770.90

Energy is purchased under the optional or, increment rate, computed as indicated herewith.

First 200 kw-hr. consumed during month at 7c per kw-hr.

Next 200 kw-hr. consumed during month at 6c per kw-hr.

Next 200 kw-hr. consumed during month at 5c per kw-hr.

Next 1400 kw-hr. consumed during month at 4c per kw-hr.

Next 3000 kw-hr. consumed during month at 3c per kw-hr.

And all energy consumed per month in excess of 5000 kw-hr. at the rate of 2.75c per kw-hr.

To illustrate, let us consider, for example, the month of February, 1928, when 18,400 kw-hr. were consumed. We then have

200 kw-hr. at 7c	$ 14.00
200 kw-hr. at 6c	12.00
200 kw-hr. at 5c	10.00
1400 kw-hr. at 4c	56.00
3000 kw-hr. at 3c	90.00
Or for the first 5000 kw-hr.	$182.00

That amount of energy charged for at the rate of 2.75c was equal to the difference between 18,400 kw-hr. and 5000 kw-hr., or 13,400 kw-hr., for which amount $368.50 was charged. The total was then equal to the sum of $182.00 and $368.50, or $550.50.

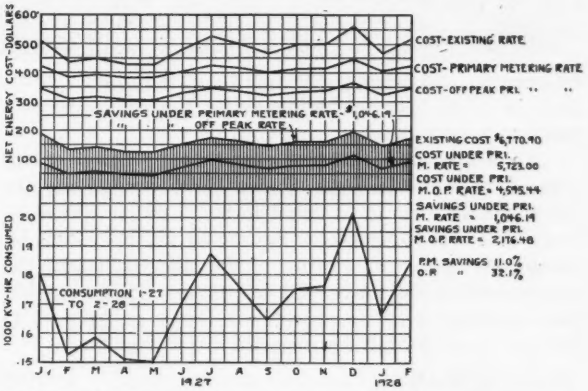
Deducting the regular discount, the net charge became $516.74.

*Consulting Engineer, Milwaukee, Wis.

[1]Reducing Purchased Power Costs in a Steel Plant, page 992, Sept. 15, 1928 issue.

WHAT CAN BE DONE HERE?

In a case of this kind and under the schedule of rates prevailing in the locality in question, either the unlimited primary metering or the off-peak primary metering rates are applicable. Under either of these, it is required that the consumer provide the necessary transformer, or transformers, the metering and switching equipment and the substation space or building.



POWER COST DATA FOR A PRINTING AND LITHOGRAPHING PLANT. THERE IS ILLUSTRATED THE SAVINGS POSSIBLE WITH VARIOUS KINDS OF RATES

Let us give consideration, first to the unlimited primary metering rate under which the first 200 kw. of demand is charged for at the rate of $2.00 per kw. per month and all in excess of 200 kw. at the rate of $1.50 per kw. per month.

The energy proper is charged as follows:

First 25,000 kw-hr.	1.25c per kw-hr.
Next 25,000 kw-hr.	1.10c per kw-hr.
Next 50,000 kw-hr.	1.00c per kw-hr.
Next 50,000 kw-hr.	.90c per kw-hr.
Next 50,000 kw-hr.	.80c per kw-hr.
All over 200,000 kw-hr.	.75c per kw-hr.

From the above combined demand and energy charges is deducted a regular discount of 5 per cent on the first $25.00 and an additional 1 per cent on the balance. In addition there is a coal factor addition or deduction dependent upon the actual cost of coal to the utility, a factor which will for the sake of simplicity be disregarded in this discussion.

Measured demand is not used in billing. Instead a billed demand is employed. This is determined by dividing the product of the measured demand and 80 (standard power factor value), by the average monthly

power factor of the plant system. Assuming, in any specific instance, that the measured demand is 230 kw. and that the average monthly power factor is 60 per cent. The billed demand will then be equal to 230 × 80 ÷ 60 = 306 kw.

On the other hand, however, should the plant's average monthly power factor be 100 per cent, the billed demand would, instead, equal 230 × 80 ÷ 100 = 184 kw., with a consequent demand charge of 184 × $2.00 = $368.00 that instead of

200 kw. at $2.00	$400.00
106 kw. at 1.50	159.00
or, a total of	$559.00

The monthly saving would obviously be equal to $191.00.

Thus is evident the financial advantage of a high degree of power factor.

Again, going back to a consideration of the printing plant under discussion, it has been found from tests made that the actual demand is ordinarily equal to 80 kw. and that the average monthly power factor is 57 per cent.

What would have been the cost for the 18,400 kw-hr. of energy used during the month of February, 1928, had the plant been operating under the unlimited primary metering rate?

We will assume that the power factor has been increased to 100 per cent. Under these conditions, the billed demand would be equal to 80 × 80 ÷ 100 = 65 kw. This would naturally appear to be the billed demand but, because of a ruling of the utility company the minimum demand which will be billed is 100 kw. so that as a consequence, with any power factor of from 65 to 100 per cent the billing remains

100 kw. at $2.00	$200.00
18,400 kw-hr. of energy at 1.25c per kw-hr.	230.00
or, a total of	$430.00

Less the regular discount the net bill would be. $424.70 with a resulting energy cost reduction of $516.74 — $424.70 = $92.04.

Is Further Reduction Possible?

Yes, if the consumer can and will arrange the operating hours of his plant to conform to the off-peak requirements as already explained. This particular plant can well arrange for a 20-kw. demand during the peak load hours, so that the resulting demand charge would be

20 kw. at $2.00	$ 40.00
80 kw. at 1.00	80.00
Total demand charge	$120.00
Energy charge as above	230.00
Total	$350.00
Discount	4.50
Net cost	$345.50

or a net saving for the month equivalent to $516.74 — $345.50 = $171.24.

Consideration of some one month as has been done in the few preceding examples is in reality a more or less poor and perhaps unconvincing way of presenting facts and, as a consequence, a practice employed by the writer has been to make a detailed study and investigation of some typical business year. Future consumptions of energy can, of course, not be in any way foretold and, as a consequence, it appears more satisfactory to take under consideration some past 12 or even 14-mo. period and compare the cost of energy to the consumer during that interval to what it would have been had the consumer been operating under some other rate or rates. Accordingly, for this particular case, we have

Month	Consumption Kw-hr.	Under Existing Rate	Under Primary Metering Rate	Under Off-Peak Primary Metering Rate
Jan., 1927	18,160	$510.53	$421.73	$322.73
Feb.	15,280	436.05	386.09	306.89
March	15,840	450.53	393.02	313.82
April	15,120	431.91	384.11	304.91
May	15,040	429.84	383.12	303.92
June	17,040	481.57	407.87	328.67
July	18,720	525.02	428.66	349.46
Aug.	17,680	498.12	415.79	336,59
Sept.	16,480	467.08	400.94	321.74
Oct.	17,520	493.98	413.85	334.61
Nov.	17,600	496.05	414.80	335.60
Dec.	20,160	562.26	446.46	367.28
Jan., '28	16,640	471.22	402.92	323.72
Feb.	18,400	516.74	424.70	345.50
Total	239,680	$6,770.90	$5,723.06	$4,595.44

Thus it is evident that for the 14-mo. period under consideration, the savings under the unlimited primary metering rate would have been $1047.84 and under the off-peak primary metering rate, $2175.46. Segregated, the monthly savings would be

Month	Savings Under Unlimited Primary Metering Rate	Savings Under Off-Peak Primary Metering Rate
Jan., '27	$ 88.80	$187.80
Feb., '27	49.96	129.16
Mar., '27	57.51	136.71
Apr., '27	47.80	127.00
May, '27	46.72	125.92
June, '27	73.70	152.90
July, '27	96.36	175.56
Aug., '27	82.33	162.15
Sept., '27	66.14	145.34
Oct., '27	80.13	159.37
Nov., '27	81.25	160.45
Dec., '27	115.15	194.98
Jan., '28	68.30	147.50
Feb., '28	92.04	171.64

Upon an annual basis, the yearly savings under the unlimited primary metering rate would be equal to $898.08 and under the off-peak primary metering rate, $1864.68.

Naturally, in order to make the change in rates some engineering service must be paid for, plant remotoring done and transformers, metering and switching equipment and static condensers purchased and installed. This is estimated to cost the consumer approximately

$3000. Fixed and operating charges should not be more than 16 per cent, or $480 per yr.

Thus it is evident that under the unlimited primary metering rate the net savings would be $418.08 and under the off-peak primary metering rate $1384.68.

In either case, the investment would prove desirable; particularly so in the latter.

In concluding, the writer wishes to point out the reductions in power costs possible but, as in the case of many other engineering problems, each installation requires its own solution.

Generator Voltage Regulator Maintenance

By R. B. Greenwood

AT THE MOCCASIN station of the City of San Francisco, the voltage of each of the four 20,000-kv.a. generators is controlled by individual regulators of the extended broad range type. The 140-kw. exciters are direct-connected to the generators, a 300-kw. motor-generator serving as a spare exciter.

To insure successful and dependable operation, the contacts, which are the only parts of the regulators to wear appreciably, must be kept in good condition. Each regulator is provided with 14 differential relays requiring two contacts each. Including the main contacts, each voltage regulator utilizes 30 contacts. Since a regulator is provided for the spare exciter, there are 150 contacts that must be inspected and dressed.

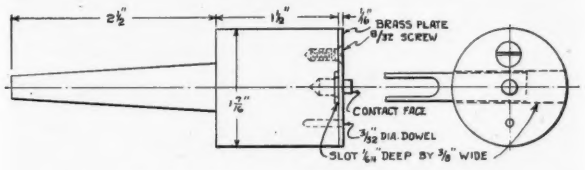


FIG. 1. JIG FOR RELAY CONTACTS

In order to maintain the regulator contacts economically and recondition them so that they would be as good as new contacts until worn out, a No. 125 Goodell-Pratt toolsmith's lathe was installed. This lathe is belt-connected to a ¼-hp. single-phase motor. While purchased primarily for dressing regulator contacts, this lathe has also proven useful for many small jobs, such as making small insulating bushings and washers, and for drilling holes up to ⅜ in. diameter. The lathe is mounted on the electrician's workbench.

Since the stationary differential relay contacts cannot be held in an ordinary chuck, the jig illustrated in Fig. 1 was constructed for dressing the stationary contacts of the shunting relays. There are 10 pairs of shunting relay contacts in each regulator.

The jig consists of a slotted steel head provided with a No. 1 Morse taper shank for fitting into the live spindle. The flat spring to which the stationary contact is revetted is clamped in the slot by means of a brass plate screwed to the face of the jig. The contact can be inserted or removed by loosening the one screw. The movable shunting relay contacts are not spring mounted, hence fit in the universal chuck. A lathe tool is used to face both of the shunting relay contacts, finishing being done with a fine cut file before the contacts are removed from the lathe.

Movable main contact and the movable contacts of the master and vibrating relays are dressed by means of fine stone, a lathe tool not being suitable for this work. The corresponding stationary contacts are dressed by hand on a flat stone, the lathe not being used. The contacts referred to in this paragraph require little attention. The lowest speed, 490 r.p.m., is most suitable

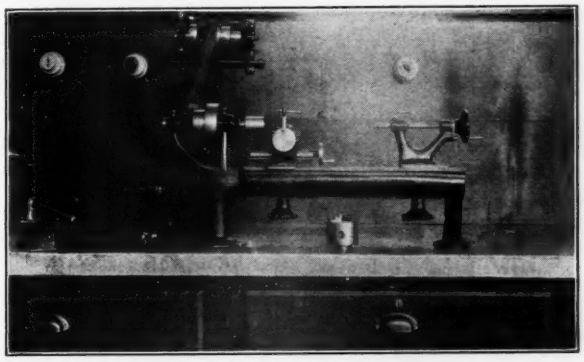


FIG. 2. TOOLSMITH'S LATHE USED FOR RECONDITIONING CONTACTS

ROUTINE INSPECTION SHEET
VOLTAGE REGULATOR
City and County of San Francisco — Moccasin Power Station

FIG. 3. REGULATOR INSPECTION SHEET USED AT MOCCASIN STATION

for dressing contacts by means of the lathe tool. For finishing with a stone or file, the highest speed, 2200 r.p.m., is used.

Each voltage regulator is thoroughly inspected monthly. During inspections any contacts showing unusual wear are replaced by new ones, or by contacts that have been reconditioned before the inspection was begun. This is done in order to have the regulator out of service the minimum length of time.

Figure 3 shows the regulator inspection sheet originated and used at Moccasin. This sheet is filled in, mostly by check marks, by the station electrician as the inspection is made, and serves as a record of each regulator's condition for that particular month.

Central Station for Coal Mine Service

MINE-MOUTH PLANT AT NORTONVILLE, KY., BURNS LOW-GRADE SCREENINGS IN PULVERIZED FORM AND SECURES WATER FROM ARTIFICIAL LAKE

FOR THEIR new steam electric generating station in Hopkins County, Kentucky, the Kentucky Electric Power Corporation chose a mouth-of-mine location. The power company was organized by stockholders in a system of coal mines for the purpose of creating a reliable market for low-grade screenings from the mines at Nortonville and to supply electric power to the various mines of that vicinity and to other consumers. The principal part of the power generated is consumed

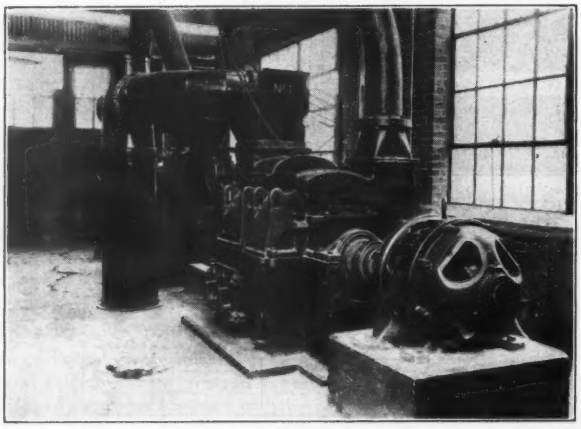


FIG. 1. COAL PULVERIZING MILLS

by coal mines controlled by owners of the power company.

COAL PREPARATION AND HANDLING

Coal screened through ⅜ in. mesh is delivered by the mines onto a 16-in. inclined belt elevator. The belt transfers the coal at an elevation of approximately 20 ft. to an inclined scraper conveyor, which runs at right angles to the belt and extends across the switching tracks into the coal tower above the coal bunkers. Falling from the conveyor, the coal passes through an automatic weighing scale to a horizontal distributing conveyor over the storage bunkers. Two hundred tons is the capacity of the storage bunkers. That amount will supply the station two to four days.

Pulverized coal firing equipment is used and the layout has proved very practical and economical in operation.

Two impact type pulverizing mills, having a combined capacity of 5½ t. per hr., prepare the coal and discharge it through suitable piping to the four burners. The burners are of the lopulco type. They are mounted in the tile arch and discharge vertically downward into the furnace. The furnace has a hollow tile front wall, through which additional air for combustion is drawn into the flame. The sides of the furnace are of fin tube construction. A water-tube screen covers the ash pit. The rear of the furnace has a fire brick wall up to the tubes of the boiler which cover the rear of the combustion chamber.

Steam is generated in a boiler of the four-drum bent tube type, having 8343 sq. ft. of heating surface. A superheater is installed between the first and second banks of tubes. The boiler, steam piping, turbine and auxiliaries are designed to operate at present at 200 lb. gage pressure but allowance has been made to raise the working pressure to 300 lb. when the plant is extended.

TURBINE FOR WIDE LOAD RANGE

In the design of the turbine especial care was taken to secure economical operation over a wide load range. The speed of the main unit is 3600 r.p.m. and the rated capacity 5000 kw. The condenser is a two-pass surface type. Steam jet air ejectors in two stages remove the air.

Two hotwell pumps are installed. One is driven by

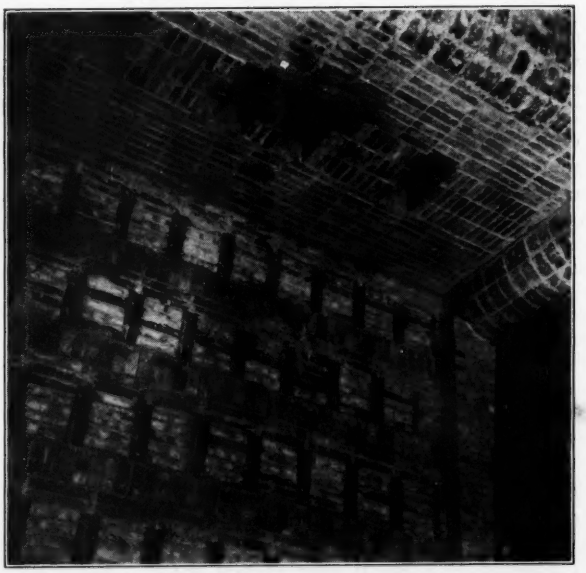


FIG. 2. FRONT WALL AND ARCH OF FURNACE INTERIOR

a steam turbine, the other by a 10-hp. motor. Condensate flows from the hotwell pumps through the oil cooler to the open heater. The heater discharges to a surge tank. Hot water flows from the surge tank to either of the two turbine driven feed pumps. The latter have a rating of 300 g.p.m., under a static head of 900 ft. Two 4-in. feed lines serve the boiler. One is arranged for hand control and the other for automatic control.

Dual drive is provided for the circulating pump. One end of the shaft is connected through reduction gears to a 2850 r.p.m. steam turbine and a 200-hp. motor is direct connected to the opposite end of the pump shaft. The governor of the turbine is easily adjusted to place the load on either drive, the other being ready to maintain continuous service in case of accident to the acting drive.

In addition to the gain in dependability by the two drives, electrical and steam, which are used on the circulating pump and on the hotwell pumps, it is a valuable arrangement for controlling the station heat balance so that the proper amount of exhaust steam is available to heat the boiler feedwater.

Artificial Lake Supplies Water

Source of water supply consists of an artificial lake covering 40 acres and 28 ft. in depth in the deepest part. The dam is an earth fill 1300 ft. long, rising several feet above the spillway level. Small streams and run-off water from rainfall promise to keep an abundant supply of water for the spray pond and for make-up.

Situated at the lake is an electric pumping station which pumps the water to the plant through a 6-in. pipe line approximately half a mile in length. Near the power plant are three reserve supply tanks for emergency use, located on elevated ground. The 6-in. pipe line has several branches—one to each power plant, the old and the new, and one to the mine. In the new station, the feedwater makeup is a small part of the water used. Most of it flows to the spray pond a short distance north of the building. In order to build the plant at the mine, it was necessary to use a spray pond in connection with the circulating water system. There is no stream in the valley.

With an area of 30,000 sq. ft., the spray pond accommodates two fields of sprays. It is enclosed by a 12-in. concrete wall, reënforced by a backing of slate and earth. The bottom is of clay. Screens in duplicate protect the intake from foreign matter. In case there is too much water in the pond, or in case of stoppage of the supply water, a small pump will furnish boiler feedwater make-up from this source.

Joined to the main steam header is a tap header which furnishes steam through a pressure reducing valve and a desuperheater to a line connecting with the old plant near by. Four 4½-in. pop valves protect the lower pressure system against failure of the pressure reducing valve. Provision is made to supply steam from the low-pressure system to the new plant through a nonreturn valve. This arrangement is useful in heating while the plant is idle, or for supplying steam from the old station to run various steam driven machines in the new station.

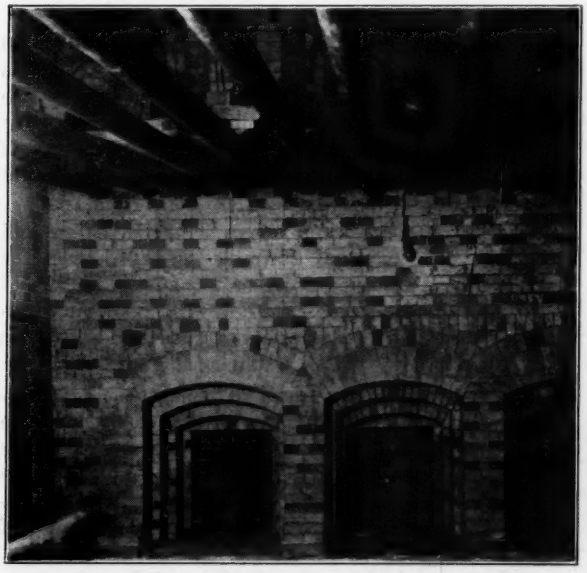


FIG. 3. VIEW OF FURNACE BELOW THE SCREEN TUBES

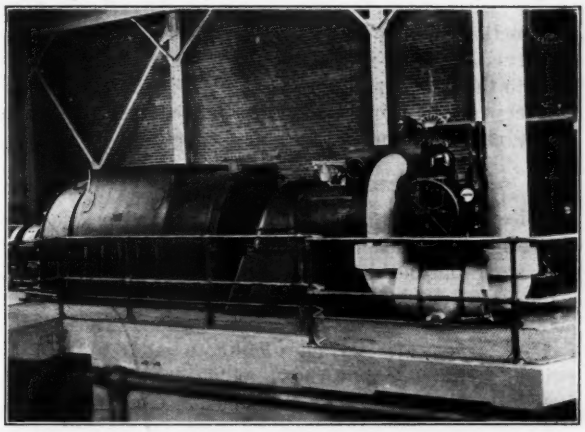


FIG. 4. TURBINE AND GENERATOR

Instruments Aid Operation

Records of the steam generated are furnished by a steam flow meter which also assists the fireman in regulating the fuel and air proportions to the proper ratio. There is also a recording thermometer pen to show flue gas temperature and a draft indicator which shows draft near the top of the furnace. Another steam meter is installed in a line which furnishes steam on demand to the local coal mine. The meter for measuring station water consumption has been mentioned. An automatic coal weighing scale with a trip counter registers the coal supplied to the bunkers.

No forced draft is supplied, secondary air being induced into the furnace through the ports in the hollow front wall. The induced draft fan is driven by a 60-hp. variable speed enclosed motor. The stack is of steel, unlined. It has a diameter of 7½ ft. and reaches 100 ft. above the floor of the boiler room. It is possible to damper off the induced draft fan and operate on natural draft through a bypass section of the breeching.

Ash is handled by a steam jet system which is in-

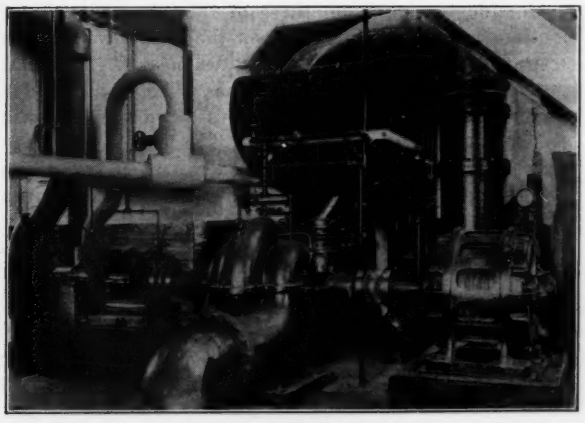


FIG. 5. CONDENSER AND CIRCULATING PUMP

stalled with connections to ports in the ash-pit floor and to the soot hoppers. The ash-pit floor is of hollow construction. Air is drawn through the ducts in this floor to the pulverizing mills. The air is thereby heated before passing through the grinding chamber and fan of the mill into the burner manifold pipes.

Electrical Features

Electric oil switches are located on the same floor as the generator and instrument panels. The incoming line from the old power house is rated at 2000 kv-a. There is a 1500-kv-a. feeder to nearby customers and a 5000-kv-a. feeder to the outdoor substation. These three feeders have knife switches on both sides of the oil switch, mounted on overhead panels. There is also a 1000-kv-a. station feeder to the station transformers on the west side of the building. A separate feeder is also installed for the 200-hp. 2300-v. circulating pump

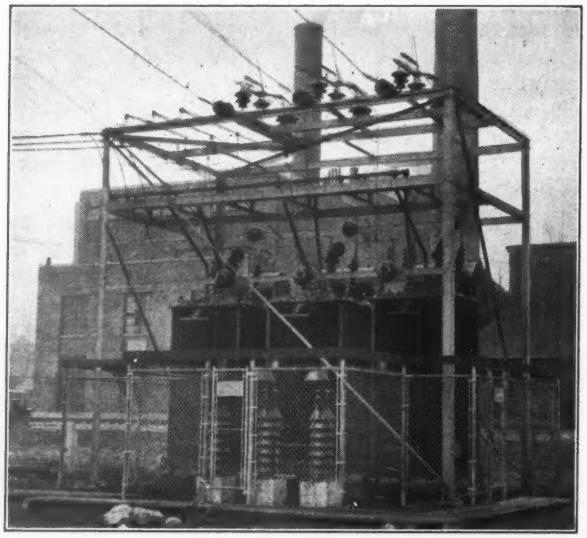


FIG. 6. OUT-DOOR SUB-STATION

motor. The generator switch completes the present installation.

House transformers step the voltage down to 220 v. for use by all the station motors, except the circulating pump drive. There is also a tap on the transformers which delivers the usual 110 v. for station lighting.

Outside service is on three of the oil switches just mentioned. The tie line between the two power houses serves also as a feeder to the mines nearby. The old system provides these connections. The small feeder at generator voltage is intended to serve the domestic load at Nortonville and near by. The large feeder connects to the substation transformers, which raise the voltage to 33,000 v. for highline service to coal mines and other consumers at a distance.

Electric control panels are equipped with the remote oil switch controls. The two exciter panels carry disconnect switches, rheostats, ammeters, volt meters and time relays. The remaining panels carry the generator field rheostat control, governor control, automatic voltage regulator and synchroscope, with the usual volt meters and ammeters for the various feeders.

In the present situation, as to operation, no efficiency tests have been run. The instruments installed, however, give a good account of what is being done.

Steam is maintained in the old plant to serve the coal tipple. This makes an inexpensive method of standing in readiness should the new plant need help. It is possible to lighten the load in case of trouble by calling into service the previously used sources of power at some of the mines.

One engineer and a fireman on each shift operate the complete station. There is a coal man during the day and a helper at night, who does the oiling and janitor work and removes ashes from the furnace. The same crew of men will easily be able to operate the station when the capacity is doubled. The addition will be started in the near future.

Refrigeration for the Cooling of Milk

Some Facts and Figures on the Checking-up of the Necessary Equipment. By A. G. Solomon

IN A RECENT issue of Power Plant Engineering* there appeared a short discussion regarding the "Use of Accumulator Effect in Brine Cooling." In the plant under discussion, there was a brine tank for cooling milk in which the operator placed 24, 100-lb. ice pans which he kept filled at all times to serve as an accumulator in times of heavy demand and thus to keep the brine temperature down.

At 32 deg. F. the temperature seemed more easily controlled than at higher or lower temperatures. The tank was run at 8 to 12 deg. below zero. The questions involved were: 1. Which was the better way to operate this tank: using the ice pans referred to or using brine alone for cooling? 2. If the brine was at zero and the ice pans were used, what would be the temperature of the ice and how many more B.t.u. would be necessary at this temperature than when the brine is at 30 deg. above zero?

This method of operation has some features that can be looked into to good advantage.

In the first place, why is a temperature of 8 or 10 deg. below zero needed in the handling of milk? This extremely low temperature work looks more like ice cream hardening than milk cooling; and we all know that the maintaining of below zero temperatures is costly. It would seem that higher temperatures would be just as satisfactory.

Several other questions arise. First, is the method of cooling the brine and the milk the best known for that particular service and second, is all the cooling of the brine done in a tank equipped with ammonia evaporating coils or is a double-pipe or shell and tube type brine cooler used? Which would be the better?

Rate of heat transfer from the brine to the evaporating coils is from 10 to 15 B.t.u. per hr. per sq. ft. pipe surface per deg. temperature difference when the brine tank and coils are used. With the double-pipe or the shell and tube type brine coolers the rate of heat transfer is from 60 to 150 B.t.u. depending on the velocity of the brine.

*June 1 issue, page 644.

Which of the three evaporating systems is the best and would give the most uniform brine temperature and by so doing cool the milk to the desired temperature in the shortest time and at the lowest cost?

It is not usual practice to have an agitator in a small brine cooling tank but I know from experience that agitation is necessary if good results are to be obtained. Without an agitator, the speed of brine flow depends entirely on the movement caused by the pump suction and the brine returning. And there is often a real short circuit and the warm brine travels to the pump suction in almost a direct line. When such is the case, use two perforated headers. One header will be just below the surface of the brine and will distribute the returning brine evenly over the tank. The other perforated pipe will be a continuation of the pump suction and will be at the bottom of the tank at the opposite side to the return header. This arrangement will increase the circulation and will give all the ammonia pipe surface a chance to do some work.

If the milk is pasteurized by being subjected to about 160 deg. and then cooled by the use of water to a temperature of 85 deg., the refrigerating machine will be required to lower the temperature from 85 to 35 deg. A brine temperature of between 5 and 10 deg. above zero is general practice for the milk cooler.

Have the brine temperature at 5 deg. above zero when the cooling of the milk begins and keep the machine operating at its best efficiency during the time the cooling continues. If the temperature of the brine in the tank goes above 12 deg., it is a good indication that some part of the equipment is too small or not doing its share of the job.

Checking Up on the Plant

This will call for a checking-up on the entire plant.

To do this, the first step is to estimate the refrigerating load.

We will assume the following conditions as an example.

One thousand gallons of milk to be cooled from a temperature of 85 to 35 deg. in 4 hr. time.

$1000 \times 8.6 = 8600$ lb. of milk.

The specific heat of milk is 0.9 and the temperature difference or degrees the milk is to be cooled is 50. Then we have $8600 \times 0.9 \times 50 = 387{,}000$ B.t.u., which is the heat to be removed by the brine in 4 hr. This is equal to 96,750 B.t.u. per hour. As one ton of refrigeration is equal to the removal of 288,000 B.t.u. in 24 hr. then in one hour 12,000 B.t.u. must be taken up.

Dividing 96,750 by 12,000 gives a fraction over 8 which is the actual machine tonnage needed. To be sure that the machine capacity will take care of the usual operating losses with which we have to deal, the machine should be 10 t. rated capacity.

Estimating Amount of Brine Necessary

The next step in seeing that the plant is properly balanced is to estimate the amount of brine that must be circulated to remove the heat of the milk in the stated time.

Calcium brine must be used, owing to the low temperature carried. The specific gravity of the brine will be 1.2 and the specific heat 0.7.

The temperature rise of the brine will be 20 deg., as we shall send the brine to the milk cooler at 5 deg. and return it to the tank at 25 deg.

Then, to remove 96,750 B.t.u. from 2150 lb. of milk in 1 hr., it will be figured as follows:

W = the weight of brine necessary. Then
$96{,}750 = W \times 0.7 \times (25 - 5)$
$W = 96{,}750 \div (0.7 \times 20) = 6912$ lb.

As this calcium brine weighs about 10 lb. per gal., we shall allow 700 gal. to circulate per hr. This will require a pump of 15 gal. per min. capacity.

Now we shall see about the amount of pipe needed in the brine tank.

As a brine tank with coils is used, the rate of heat transfer from the brine to the ammonia will vary from 10 to 15 B.t.u. per hr. per sq. ft. pipe surface per deg. temperature difference. The variation in heat transfer is owing to the rate of circulation. With an agitator in the tank, it is possible to obtain the 15 B.t.u. We will allow 12 B.t.u. for our condition.

Ammonia temperature in the coils can be taken as zero which will correspond to an evaporating pressure of 15 lb.

The average brine temperature will be 15 deg.

A = area of pipe surface.
$96{,}750 = 12 \times A \times 15$
$A = 96{,}750 \div (12 \times 15) = 537$ sq. ft.
$537 \times 2.3 = 1235$ lineal feet of 1¼-in. pipe.

Checking this, we have: With a heat transfer of 12 B.t.u. and a temperature difference of 15 deg. 537 sq. ft. of pipe surface will transmit $12 \times 15 \times 537 = 96{,}660$ B.t.u. per hour from the brine to the ammonia.

By increasing the circulation or by carrying a higher temperature brine, the system will be more efficient and the coil surface could be less.

Then: With a temperature rise of 20 deg. and circulating 12 gal. of brine per min. we can remove 96,660 B.t.u. from 2150 lb. of milk per hour while lowering the temperature of the milk from 85 to 35 deg.

In the latest report of the Pulverized Fuel Subcommittee of the Prime Movers Committee of the N. E. L. A., much operating data and many records have been included. The major features of the report may be summarized as follows:

Increased use of pulverized fuel for firing boilers in public utility stations and industrial plants. In industrial plants, the estimated 1928 installed capacity will be 140,000 b.hp. for the central system and 240,000 b.hp. for the unit system. In central stations, the conditions are reversed. The installed capacity is about 130,000 for the unit system and 310,000 for the central system.

The unit system is now being applied to large boilers. Collection of coal dust and fine ash presents a problem that is being met differently in the various plants. The use of water cooled surfaces in the furnaces of pulverized fuel fired boilers for high ratings is becoming universal practice. Preheated air is being used to dry coal in pulverizing mills.

A single fact is worth a shipload of argument.

Washing and Preparation of Coal

SOME OF THE FACTORS involved in the washing and preparation of coal were discussed by H. D. Smith from the standpoint of the coal mine operator, at the Second National Fuels Meeting of the A.S.M.E. held in Cleveland. As there are few data from consumers on the extra value of clean coal, it is impossible to give a commercial value to the cleaning of it or to determine the economical point of cleaning.

The methods of Wet-washing and dry-cleaning processes are used, the principle of separating the impurities being based on the difference between the specific gravities of the coal and the refuse.

Some coals are cleaned not only to lower the ash but also to lower the sulphur content when it is in pyritic form. Some engineers believe that organic sulphur can be removed by washing, a feat which was believed impossible some years ago.

No Data Available On Increased Value of Cleaned Coal

Cleaning only to sizes down to ¼ in., a raw coal of 10 per cent ash may be cleaned down to 7 per cent ash at 20 cents per ton. In order to clean this coal down to 6 per cent ash 10 to 20 cents per ton more might be added, making a total cost of 30 to 40 cents.

If the consumer understood the value of an efficiently cleaned coal, better results from cleaning plants could be obtained, but as yet there are no data that will give the coal operator a knowledge of the effect of coal cleaning on marketability.

Preparation of coal starts at the face in the mine and continues until the coal is consumed. It is an important factor in transportation, it affects the burning, it bears directly on domestic heating costs, and with public utility and industrial plant users affects production costs. There is no question that clean coal has a greater value than dirty coal, and should command higher returns in price and a great volume of sales or greater marketability.

From an operating standpoint, the cost of cleaning is made up of the four factors of power, labor, maintenance and overhead, the latter including depreciation and investment costs. And indirect cost in cleaning coal is the loss due to rejecting the waste and the "bank" loss in good coal which goes with the rejects because it is not possible to obtain 100 per cent efficient cleaning. These are sometimes called conversion costs.

Customers Not Willing to Pay for Extra Service

As an example, a mine may be running 2000 net tons per day with a cost of $1.75 per ton in the railroad car. Should that mine put in a cleaning plant and remove 10 per cent by weight of rejects, the cost of mining would still be $3500 but only 1800 net tons would be shipped, making the cost $1.95 per ton or 20 cents per ton conversion cost. If the operating cost for power, labor, maintenance and overhead is 20 cents, a low figure for a large washing plant, this would give a total cost of 40 cents for the cleaning process.

There is no question that the majority of coals going on the market are better prepared and cleaned than ever in the history of the coal industry in this country but it is also true in the past few years that, owing to the overproduction of the industry, coal buyers and consumers have not shown a willingness to pay for the extra preparation they have been obtaining.

When coal is sold on quality alone and a premium is paid for each 1 per cent in ash reduction, it will be possible to figure how far any plant can economically go in the cleaning and preparation of its coal.

Coal-preparation plants require a large investment in machinery, equipment and structure, ranging from $400 to $1000 per ton per hour through the plant, or on another basis from 25 to 50 cents per ton of annual output.

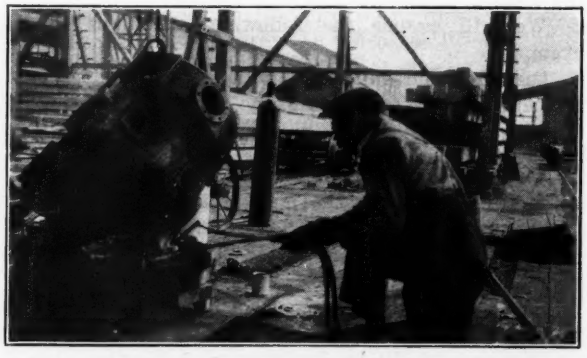
Fusing Point of Ash May Be Changed by Washing

It has also been found in washing some coals that the better the coal is washed, producing a low-ash product, the lower becomes the fusing point of ash; in other words, a raw coal running 7.5 per cent ash may have an ash fusing point of around 2700 deg. F. while after being cleaned down to 6 per cent ash, the fusing point will drop to 2500 deg. F. The reverse may be the case for other coals and in some coals there is no noticeable change in the fusing point after washing. Therefore the use to which the coal will be put should enter into the design of any cleaning plant.

Cylinder Repaired by Welding

DAMAGE IN shipment of an air compressor cylinder was such that when put in operation the wall leaked so that the compressor pumped water instead of air. The trouble was found to be a crack in the cast-iron cooling water jacket.

To save delay and expense of scrapping the cylinder and replacing with new parts, the compressor was dismantled, the crack, which extended between the two air intake ports, was veed and the casting run out into the yard on an overhead trolley. Next a small preheating furnace was built under the casting and a charcoal fire used so as to heat only the damaged portion, as shown in the illustration.



CYLINDER WAS PREHEATED BY SPECIAL CHARCOAL FURNACE

When sufficiently heated, the crack was welded in a few hours, using a good quality of cast-iron rod and flux. Total repair cost was estimated at about $25 and a delay of weeks was saved in getting the compressor at work.

How the New Televox Talks

SINCE THE "TELEVOX" or "mechanical man" was first announced by the Westinghouse Electric and Manufacturing Co., it has created a great deal of interest in all circles, engineering and otherwise. Its uncanny faculty of performing any task put to it over an ordinary telephone circuit, appeals to everybody's imagination. Recently, the Televox has been given a voice.

In all of the earlier models, the answering signal consisted of a buzzing sound, produced by means of a buzzer mounted in front of the telephone transmitter.

Owing to the possibility of errors in calling, there are times when outside persons might call the telephone equipped with the Televox in error. Should such be the case with the existing equipment, there would be nothing but a meaningless buzz to tell them of their mistake. In order to make the equipment more suitable for use over the public telephone system, the Televox has now been given a voice with which it responds in the English language or any other language that may be desired.

Previous models were not able to originate a call should something unusual happen in the substation. With the new model, however, should a circuit breaker

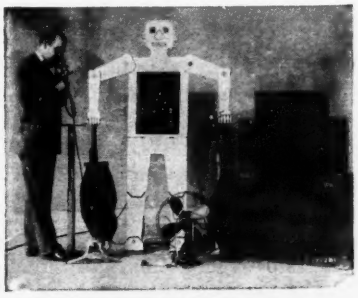


FIG. 1. MR. WENSLY SPEAKS WITH MR. TELEVOX. LIKE A PERFECT GENTLEMAN, THE AUTOMATON RESPONDS IN A SMOOTH, WELL-ARTICULATED VOICE

trip automatically or a machine overheat, or any of the various protective devices function, the machine is automatically started and the voice of the mechanism speaks to the telephone operator giving her the number of the dispatcher's telephone—thus putting through a call in the usual manner.

To give the mechanism means for emitting articulate speech of good quality, use is made of developments in the "talking movie" industry. A piece of moving picture film about 15 or 20 ft. long is spliced to make an endless loop. In the present model, two sentences are spoken. These are photographed near the two edges of the standard film; the rest of it is left blank. The sound appears in the form of closely spaced lines of various shades and widths and frequency. Individual lamps with special straight filament are arranged with lenses to concentrate the light on a very narrow portion of the film at any one time.

A small motor drives the film whenever the voice is required. A selecting mechanism in the televox lights either one of the two lamps depending upon the sentence desired. The image of the filament is projected through a narrow slot onto the speech record through which it passes to a photo-cell. A photo-cell passes current directly in proportion to the amount of light falling on it. As the lines on the film pass in front of the light, the corresponding change of currents which take place in the photo-cell are amplified through a special shielded three-stage amplifier to a volume sufficient to operate a small loud speaker. This speaker is placed in front of the telephone transmitter and is heard by the person at the other end of the telephone line exactly as though a human being were speaking the words into the transmitter.

When a call is put through to a substation equipped with a Televox having this voice attachment, the person at the remote end will hear a voice saying, "Televox speaking at Randolph 6400." This will repeat a second time if the proper signal is not given by means of whistles or other musical devices, the Televox will then hang up the receiver upon the assumption that the call is a wrong number call. In the meantime, the per-

FIG. 2. HERE IS THE LARYNX OF MR. TELEVOX

son at the distant end has heard the number of the telephone to which he has been connected and should it be a wrong number, will be able to hang up and signal the operator again to get the correct number; however, should the dispatcher have made this call with the expectation of operating something in the substation, he listens for the voice and as soon as he has verified the correctness of the number of the substation as indicated by the telephone number, he blows a blast on the proper whistle and the voice ceases, the machine then being in condition for further operation by means of the whistle notes.

High Voltage Transmission in Canada

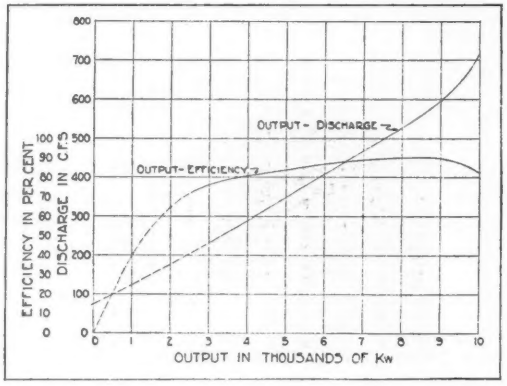
WITH THE OPENING of the new Quebec section between Paugan Falls and Toronto, the highest transmission voltage in Canada has been started with operation at 220,000 v. Twelve transformers for operation at 220,000 v. were supplied to the Gatineau Power Co. by the Canadian General Electric Co., Ltd. Nine of these transformers are rated at 19,000 kv-a., 25 cycles, and step the generator voltage up from 6600 to 220,000 v. The remaining three are rated at 20,000 kv-a., 25 cycles, and will be used to supply power to a 110,000-v. transmission system from the 220,000-v. line. The generating stations of the Gatineau Power Co. are approximately 250 mi. from Toronto.

UNLESS YOU want to be poor, don't try to keep all you get.

Balance Sheet Idea Applied to Plant Operation

SETTING-UP RECORDS THAT DIRECT OPERATION OF HYDROELECTRIC PLANT AND AID DIRECTORS IN UNDERSTANDING PRODUCTION COSTS. BY GEORGE R. SHEPARD*

EVERY POWER COMPANY, especially of a public service character, has an accounting system. Expenditures of every description receive the most meticulous attention and gross revenue is accounted for to the last penny. The treasurer's income account and balance sheet constitute the principal item of attention at director's meetings. The production of gross revenue, however, is directly under the control of the operating department and the success or failure of the power company rests primarily on the efficiency of



CHARACTERISTIC CURVES FOR 10,000-KW. HYDRO-ELECTRIC UNIT 199 FT. GROSSHEAD

operation of this department. Gross revenue must be produced before it can be accounted for. Plant operation should, therefore, be subjected to the same rigid analysis as the company's financial operations.

Granting this, we are at once confronted with the difficulty of setting up a record of operations that will be easily comparable from month to month and will be expressed in terms easily understandable by the usually non-technical director. Realization of the need for such a proper basis for an analysis led to the development of the system here described.

In the operation of any plant, a number of considerations affecting the plant output call for modifications of the ideal plant loading. Among these may be mentioned load factor, coöperation with other plants on the same system, segregation of units on different bus systems, and so on. Assuming an ideal plant loading, there are still a number of losses that enter into a consideration of plant efficiency. In order to keep track of these various losses, we have evolved a system of accounting for them to which we have given the name of "Operating Balance Sheet," so-called because we have balanced the total energy available between head water and tail water against the sum of the separate losses and the money return from the energy actually delivered to the customer.

Storage capacity of a plant is usually described in terms of acre feet, the capacity in horsepower, machinery capacity in kilowatts, output in kilowatt-hours, electric losses in percentage of load and revenue in dollars. For comparison, these must all be reduced to some common denominator and, since the dollar is the least technical and best understood term, each of the "Operating Balance Sheet" items is reduced for the final analysis to its dollar value.

Consider a plant located on a stream having a flow and storage capacity to carry the daily load and to permit a daily peak sufficient to load to capacity the entire station equipment; available head from crest to spillway to tail water, 200 ft.; station equipment: six similar hydroelectric units of 10,000 kw. each maximum capacity and a maximum efficiency of 90 per cent at 8000 kw. output. Assume the mean reservoir elevation for the month at 1 ft. below the spillway crest, giving a gross head of 199 ft. Characteristics of the unit are shown by the accompanying curves.

TABLE I. POWER-DISCHARGE CURVE FOR ONE UNIT

Load	Efficiency	Discharge	△ c.f.s./500 Kw.
3,000	76.5	233	
			28
3,500	79.0	261	
			28
4,000	80.8	289	
			29
4,500	82.4	318	
			29
5,000	84.0	347	
			29
5,500	85.5	376	
			30
6,000	86.9	406	
			30
6,500	88.0	436	
			30
7,000	88.9	466	
			31
7,500	89.5	497	
			31
8,000	89.9	528	
			32
8,500	90.0	560	
			37
9,000	89.5	597	
			47
9,500	87.5	644	
			75
10,000	82.5	719	

Experience seems to show that the average operator can best follow out his instructions as to the proper loading of the plant by means of a series of tables showing the proper number of units to operate and the proper loading of each unit for successive increments of plant capacity.

For determining the power-discharge curve from the assumed efficiency curve, the following formulas are used:

$$hp. = \frac{Q\,H}{8.8} \times e \qquad Q = \frac{hp. \times 8.8}{H \times e} \qquad Q = \frac{kw.}{0.746\,e} \times \frac{8.8}{199}$$

*Of The Niagara Falls Power Co. From a report of the Hydraulic Power Committee of the N. E. L. A.

Where hp. is horsepower, kw. kilowatts, Q discharge in cubic feet per second, H head in feet and e efficiency. Table I is taken directly from Fig. 1.

Both the theory and practice of deriving a table of plant loading for minimum discharge have been thoroughly worked out in the technical press and it is sufficient for our purpose to say that the application of the theory to Table I produces Table II, giving proper loading for minimum discharge for all loads from 5000 kw. to 60,000 kw. in steps of 500 kw.

Calculation Losses

Computing the detailed losses for one day is the next step. We will assume a daily load curve based on hourly readings of indicating wattmeters as in Table III, which also shows a distribution of this load among the six units. Losses and methods of calculating them are given below.

1. Inadequacy: That is, that loss which is due to the fact that even with the best loading at 100 per cent load factor, with the daily average discharge assumed flowing 24 hr., the plant could not operate at the best efficiency points of all units, i. e., 90 per cent.

Average discharge for the day—2957 c.f.s.

Best possible kilowatt output with 2957 c.f.s. from Table II 44,600 kw., or

1,070,400 kw-hr. (24 hr.) = a

If the plant could be operated at 90 per cent efficiency 90 per cent eff. = 15.18 kw. per c.f.s. or

kw-hr. = c.f.s. × 15.18 × 24

= 2957 × 15.18 × 24 = 1,077,600 kw-hr. = b

b — a = Inadequacy Loss = 7200 kw-hr.

2. Load Factor: Loss from operating plant beyond maximum efficiency point of all units combined during peak loads.

Kw-hr. possible at 2957 c.f.s. for 24 hr., 1,070,400 = a

TABLE II. PLANT LOADING FOR MINIMUM DISCHARGE. UNIT LOADING GIVEN IN THOUSANDS OF KILOWATTS

Plant Load	Unit No. 1	Unit No. 2	Unit No. 3	Unit No. 4	Unit No. 5	Unit No. 6	Discharge	Increase
5,000	5.0	....	....	....	....	....	347	29
5,500	5.5	....	....	....	....	....	376	30
6,000	6.0	....	....	....	....	....	406	30
6,500	6.5	....	....	....	....	....	436	30
7,000	7.0	....	....	....	....	....	466	31
7,500	7.5	....	....	....	....	....	497	31
8,000	8.0	....	....	....	....	....	528	32
8,500	8.5	....	....	....	....	....	560	32
9,000	9.0	....	....	....	....	....	597	37
9,500	9.5	....	....	....	....	....	644	47
10,000	5.0	5.0	....	....	....	....	694	50
10,500	5.5	....	....	....	....	....	728	29
11,000	....	5.5	....	....	....	....	752	29
11,500	6.0	....	....	....	....	....	782	30
12,000	....	6.0	....	....	....	....	812	30
12,500	6.5	....	....	....	....	....	842	30
13,000	....	6.5	....	....	....	....	872	30
13,500	7.0	....	....	....	....	....	902	30
14,000	....	7.0	....	....	....	....	932	31
14,500	7.5	....	....	....	....	....	963	31
15,000	....	7.5	....	....	....	....	994	31
15,500	8.0	....	....	....	....	....	1025	31
16,000	....	8.0	....	....	....	....	1056	32
16,500	8.5	....	....	....	....	....	1088	32
17,000	....	8.5	....	....	....	....	1120	37
17,500	9.0	....	....	....	....	....	1157	37
18,000	....	9.0	....	....	....	....	1194	47
18,500	9.5	....	....	....	....	....	1241	37
19,000	6.5	6.5	6.0	....	....	....	1278	37
19,500	....	....	6.5	....	....	....	1308	30
20,000	7.0	....	....	....	....	....	1338	30
20,500	....	7.0	....	....	....	....	1368	30
21,000	....	....	7.0	....	....	....	1398	30
21,500	7.5	....	....	....	....	....	1429	31
22,000	....	7.5	....	....	....	....	1460	31
22,500	....	....	7.5	....	....	....	1491	31
23,000	8.0	....	....	....	....	....	1522	31
23,500	....	8.0	....	....	....	....	1553	31
24,000	....	....	8.0	....	....	....	1584	32
24,500	8.5	....	....	....	....	....	1616	32
25,000	....	8.5	....	....	....	....	1648	32
25,500	....	....	8.5	....	....	....	1680	37
26,000	9.0	8.5	8.5	....	....	....	1717	37
26,500	....	9.0	....	....	....	....	1754	37
27,000	....	....	9.0	....	....	....	1791	37
27,500	7.0	7.0	7.0	6.5	....	....	1834	43
28,000	....	....	....	7.0	....	....	1864	30
28,500	7.5	....	....	....	....	....	1895	31
29,000	....	7.5	....	....	....	....	1926	31
29,500	....	....	7.5	....	....	....	1957	31
30,000	....	....	....	7.5	....	....	1988	31
30,500	8.0	....	....	....	....	....	2019	31
31,000	....	8.0	....	....	....	....	2050	31
31,500	....	....	8.0	....	....	....	2081	31
32,000	....	....	....	8.0	....	....	2112	32
32,500	8.5	....	....	....	....	....	2144	32
33,000	....	8.5	....	....	....	....	2176	32
33,500	....	....	8.5	....	....	....	2208	32
34,000	....	....	....	8.5	....	....	2240	37
34,500	9.0	....	....	....	....	....	2277	37
35,000	....	9.0	....	....	....	....	2314	37
35,500	....	....	0.0	....	....	....	2351	37
36,000	....	....	....	9.0	....	....	2388	35
36,500	7.5	7.5	7.5	7.0	7.0	....	2423	31
37,000	....	....	....	7.5	....	....	2454	31
37,500	....	....	....	....	7.5	....	2485	31
38,000	8.0	....	....	....	....	....	2516	31
38,500	....	8.0	....	....	....	....	2547	31
39,000	....	....	8.0	....	....	....	2578	31
39,500	....	....	....	8.0	....	....	2609	31
40,000	....	....	....	....	8.0	....	2640	32
40,500	8.5	....	....	....	....	....	2672	32
41,000	....	8.5	....	....	....	....	2704	32
41,500	....	....	8.5	....	....	....	2736	32
42,000	....	....	....	8.5	....	....	2768	32
42,500	....	....	....	....	8.5	....	2800	37
43,000	9.0	....	....	....	....	....	2837	37
43,500	....	9.0	....	....	....	....	2874	37
44,000	....	....	9.0	....	....	....	2911	37
44,500	....	....	....	9.0	....	....	2948	34
45,000	7.5	7.5	7.5	7.5	7.5	7.5	2982	31
45,500	8.0	....	....	....	....	....	3013	31
46,000	....	8.0	....	....	....	....	3044	31
46,500	....	....	8.0	....	....	....	3075	31
47,000	8.0	8.0	8.0	8.0	7.5	8.5	3106	31
47,500	....	....	....	....	8.0	....	3137	31
48,000	....	....	....	....	....	8.0	3168	32
48,500	8.5	....	....	....	....	....	3200	32
49,000	....	8.5	....	....	....	....	3233	32
49,500	....	....	8.5	....	....	....	3264	32
50,000	....	....	....	8.5	....	....	3296	32
50,500	....	....	....	....	8.5	....	3328	32
51,000	....	....	....	....	....	8.5	3360	37
51,500	9.0	....	....	....	....	....	3397	37
52,000	....	9.0	....	....	....	....	3434	37
52,500	....	....	9.0	....	....	....	3471	37
53,000	....	....	....	9.0	....	....	3508	37
53,500	....	....	....	....	9.0	....	3545	37
54,000	....	....	....	....	....	9.0	3582	47
54,500	9.5	....	....	....	....	....	3629	47
55,000	....	9.5	....	....	....	....	3676	47
55,500	....	....	9.5	....	....	....	3723	47
56,000	....	....	....	9.5	....	....	3770	47
56,500	....	....	....	....	9.5	....	3817	47
57,000	....	....	....	....	....	9.5	3864	75
57,500	10.0	....	....	....	....	....	3939	75
58,000	....	10.0	....	....	....	....	4014	75
58,500	....	....	10.0	....	....	....	4089	75
59,000	....	....	....	10.0	....	....	4164	75
59,500	....	....	....	....	10.0	....	4239	75
60,000	....	....	....	....	....	10.0	4314	

TABLE III. DAILY TOTAL AND UNIT LOAD, HOURLY READINGS

Time	Total Load, Kw.	Unit No. 1 Kw.	Unit No. 2 Kw.	Unit No. 3 Kw.	Unit No. 4 Kw.	Unit No. 5 Kw.	Unit No. 6 Kw.	Discharge c.f.s.	B	A Possible* Kw.
12:30 A	20,000	5,000	5,000	5,000	5,000	.....	.....	1,488	.....	22,400
1:30	22,000	5,000	5,000	5,000	7,000	.....	.....	1,507	.....	22,700
2:30	21,000	5,000	5,000	5,000	6,000	.....	.....	1,447	.....	21,800
3:30	20,000	5,000	5,000	5,000	5,000	.....	.....	1,488	.....	22,400
4:30	21,000	7,000	7,000	7,000	.....	.....	.....	1,398	.....	21,000
5:30	24,000	8,000	7,000	9,000	.....	.....	.....	1,591	.....	24,200
6:30	32,000	8,000	8,000	6,000	10,000	.....	.....	2,181	.....	33,200
7:30	40,000	8,000	8,000	9,000	9,000	6,000	.....	2,656	.....	40,200
8:30	52,000	9,000	9,000	8,500	8,500	8,500	8,500	3,434	.....	52,000
9:30	54,000	9,000	9,000	9,000	9,000	9,000	9,000	3,582	.....	54,000
10:30	55,000	9,500	9,500	9,500	9,000	9,000	8,500	3,680	.....	55,100
11:30	56,000	9,500	9,500	9,500	9,500	9,000	9,000	3,770	.....	56,000
12:30 P	44,000	9,000	9,000	9,000	8,500	8,500	.....	2,911	.....	44,000
1:30	50,000	8,500	8,500	8,500	8,500	8,000	8,000	3,296	.....	50,000
2:30	58,000	10,000	10,000	9,500	9,500	9,500	9,500	4,014	.....	58,000
3:30	56,000	9,500	9,500	9,500	9,500	9,000	9,000	3,770	.....	56,000
4:30	55,000	9,500	9,500	9,000	9,000	9,000	9,000	3,676	.....	55,000
5:30	58,000	10,000	10,000	9,500	9,500	9,500	9,500	4,014	.....	58,000
6:30	59,000	10,000	10,000	10,000	10,000	9,500	9,500	4,164	.....	59,000
7:30	60,000	10,000	10,000	10,000	10,000	10,000	10,000	4,314	.....	60,000
8:30	55,000	9,500	9,500	9,000	9,000	9,000	9,000	3,676	.....	55,000
9:30	50,000	10,000	10,000	10,000	10,000	10,000	.....	3,595	50,000†	54,300
10:30	45,000	9,000	9,000	9,000	9,000	9,000	.....	2,982	.....	45,000
11:30	35,000	7,000	7,000	7,000	7,000	7,000	.....	2,330	.....	35,200
Total.....	1,042,000	.....	.....	.....	.....	.....	.....	70,964	1,050 200	1,054,500
Average.....	.....	.....	.....	.....	.....	.....	.....	2,957	.....	.....

*The kilowatt shown in this column are taken from Table II giving the maximum kilowatt possible with the corresponding discharge.

†It is assumed here that No. 6 is out of service for repairs and column B shows the maximum kilowatt possible with 5 machines in service. Tables similar to Table II should be drawn up showing best possible kilowatt with one or more machines out of service.

Kw-hr. possible with the obtaining variation of load (the sum of column A, Table III), 1,054,500 kw-hr. = b.

Loss due to load factor; a — b = 15,900 kw-hr.

3. Shut-Downs for Repairs, etc.: This is the difference between best possible kilowatt-hours with all machines running and best possible kilowatt-hours with the given machines shut down; in this case, 4300 kw-hr.

4. Operation: It may not be possible at all times to operate the plant in accordance with Table II, so the difference between Column B and the actual kilowatt-hours produced must be charged against unavoidable operating conditions or careless operation.

1,050,200 — 1,042,000 = 8200 kw-hr.

TABLE IV. SUMMARY FOR ONE MONTH OF THE LOSSES CALCULATED DAILY

Date	Produced	Inadequacy	Load Factor	Shut Downs	Operation	Discharge c.f.s. Hrs.	Kw-hr. at 15.18
1	1,042,000	7,200	15,900	4,300	8,200	70,964	1,077,600
2	1,040,800	7,900	23,300	.....	11,100	71,340	1,083,100
3	1,008,000	1,700	10,200	10,000	6,200	68,256	1,036,100
4	1,036,600	5,300	16,300	.....	3,100	69,900	1,061,300
5	957,500	1,500	14,100	.....	400	64,124	973,500
6*	620,000	2,700	5,000	.....	11,000	42,080	638,700
7	990,000	1,000	10,200	.....	5,400	66,300	1,006,600
8	1,010,500	3,900	15,900	3,500	4,500	68,399	1,038,300
9	1,056,000	5,800	14,000	.....	400	70,900	1,076,200
10	1,050,000	6,600	14,500	.....	1,100	70,640	1,072,200
11	1,059,000	6,700	13,600	200	....	71,100	1,079,500
12	1,027,800	2,900	13,800	.....	.....	68,800	1,044,500
13*	650,000	7,600	2,600	.....	17,000	44,619	677,200
14	1,012,000	100	8,000	.....	....	67,210	1,020,100
15	1,055,400	6,700	7,600	5,000	..	70,800	1,074,700
16	1,054,400	7,700	9,800	...	1,400	70,710	1,073,300
17	1,085,500	5,200	10,400	1,200	4,500	72,900	1,106,800
18	1,069,000	7,600	11,300	.....	2,100	71,805	1,090,000
19	1,026,000	2,200	10,800	...		68,440	1,039,000
20*	620,000	4,700	1,500		7,100	41,740	633,500
21	1,000,000	1,700	10,400	...	..	66,680	1,012,100
22	1,053,100	5,600	7,700	....	..	70,244	1,066,400
23	1,047,500	4,900	8,500	....		69,894	1,060,900
24	1,044,500	5,300	11,000	.....	500	69,916	1,061,300
25	1,042,500	4,200	13,000	....	500	69,848	1,060,200
26	1,000 200	1,000	5,000	....	400	66,300	1,006,600
27*	600,100	1,200	2,000	.....	5,100	40,090	608,400
28	1,005,400	1,800	12,200	....	.....	67,155	1,019,400
29	1,045,000	4,000	13,400	....	.	69,991	1,062,400
30	1,050,100	7,500	15,800	.....	2,100	70,846	1,075,500
	29,359,100	132,200	327,800	24,200	92,100	1,971,991 2,739	29,935,400

Kw-hr. at 100% eff. $= \frac{2739 \text{ c.f.s.} \times 199 \times 0.746 \times 720}{8.8} = 33,247,800$

Loss due to inefficiency = 3,312,400 kw-hr.

Note: *Sundays.

At the end of each month, these daily losses are summarized in Table IV. These monthly loss details are given their dollar values as in Table V.

Production

We will now assume a division of the kilowatt-hours produced as follows:

300 kw. to local domestic service at 25 per cent load factor sold at $0.03 per kw-hr. on watthour meter basis, 54,000 kw-hr.

2000 kw. to local industries at 65 per cent load factor sold on a peak basis at the equivalent of $0.01 per kw-hr.; sold in such a way that the kw. billed is equivalent to 1,200,000 kw-hr.; actual delivery, 936,000 kw-hr.

TABLE V. MONTHLY LOSS SUMMARY AND EVALUATION

		Base price $0.005 per kw-hr.
The water used would produce at 100% eff.	33,247,800 kw-hr. worth	$166,239.00
Kw-hr. actually produced	29,359,100 kw-hr. worth	146,795.50
Loss due to inefficiency	3,312,400 kw-hr. worth	16,562.00
Loss due to inadequacy	132,200 kw-hr. worth	661.00
Loss due to load factor	327,800 kw-hr. worth	1,639.00
Loss due to shut downs	24,200 kw-hr. worth	121.00
Loss due to operation	92,100 kw-hr. worth	460.50
	33,247,800	$166,239.00

TABLE VI. MONTHLY PRODUCTION SUMMARY AND EVALUATION

Kw-hr. produced	29,359,100 kw-hr.	$146,795.50
Delivered to far end of line	26,848,000	134,240.00
Delivered to local domestic	54,000	270.00
Delivered to local industries	936,000	4,680.00
Station service, etc	108,000	540.00
Line loss	1,413,100	7,065.50
	29,359,100	$146,795.50

TABLE VII. MONTHLY PRODUCTION AND BILLING

	Kw-hr. Used	Kw-hr. Billed	Amt. Billed $	Amt. at 0.005 $	Above $	Below $
Long distance	26,848,000	30,100,000	120,400	150,500	.	30,100
Local domestic	54,000	54,000	1,620	270	1,350	.....
Local industrial	936,000	1,200,000	12,000	6,000	6,000	.....
	27,838,000	31,354,000	134,020	156,770	7,350	30,100
		27,838,000				

Paid for but not used..... 3,516,000 kw-hr.

Delivered to local domestic	54,000 kw-hr.	$ 270.00
Delivered to local industrial	936,000 kw-hr.	4,680.00
Delivered to long distance	26,848,000 kw-hr.	134,240.00
Paid for but not used	3,516,000 kw-hr.	17,580.00
Sold at rates above 0.005 per kw-hr		7,350.00
		$164,120.00
Billed		134,020 00
Sold at rates below 0.005		30,100.00
		$164,120 00

TABLE VIII. FINAL BALANCE

Water discharged	$166,239.00
Paid for—not used	17,580.00
Sold at rates above 0.005	7,350.00
	$191,169.00
Inefficiency	16,562.00
Inadequacy	661.00
Load factor	1,639.00
Shut downs	121.00
Operation	460.50
Station service, etc	540.00
Line loss	7,065.50
Sold at rates less than 0.005	30,100.00
Total losses	$57,149.00
Revenue (billed)	134,020.00
	$191,169.00

150 kw. for station service, unit auxiliaries, etc., 108,000 kw-hr.; the balance delivered to long transmission line, sold at far end of transmission line with 5 per cent line loss.

All the various elements of produced and delivered energy, with their dollar values, can be listed as in Tables VI and VII—the latter showing also details of monthly billings and the like.

Balance Sheet

To conclude the work, essential items are taken from Tables V, VI and VII, to be set up in Table VIII as the balance sheet or financial comparison of detail losses and revenue.

This "Balance Sheet" idea may also be applied to steam power plants, starting with the heat value of the coal and working through the different energy losses to gross operating revenue.

Illinois Chapter A.S.H. & V.E. Installs Officers

On October 8, the Illinois Chapter of the A. S. H. & V. E. met at the Sherman Hotel for the purpose of electing officers for the coming year. H. G. Thomas, who, for 8 yr., served as secretary, was elected president, and was presented with a suitably engraved gold watch in appreciation of services rendered the chapter. T. H. Monaghan was elected vice-president, C. W. Deland, secretary, and August Kehm, treasurer; J. H. O'Brien, R. B. Hayward and E. P. Heckel were elected to the Board of Governors.

After dinner, Harry L. Fogleman gave an interesting lecture on "The Engineer—Should He Be a Salesman?" Mr. Fogleman outlined the factors that enter into service, as quality, quantity and method or mode of conduct. In all transactions, the salesman, customer, goods and sale are closely related and the success of an individual depends upon four personal qualities: ability, reliability, endurance and action. The first letters of these four words spell area. A man's worth can therefore be represented by the area of a square, each side of which is formed by one quality and these qualities can be developed by the individual so as to improve his worth to society or industry. To be successful, every individual must be able to sell his services or product to the best advantage.

Motor Heats Because of Grounded Circuit

RECENTLY AN unusual case of electrical trouble came under my observation and because it was found only after it had been figured out on paper, I assume it will be of interest to others.

We have a compression machine for breaking concrete test cylinders, which is powered with a ½-hp., 220-v., 60-cycle, 3-phase motor which is fed by a bank of three single-phase transformers with 2300-v. primaries and 230/460-v. secondaries connected as shown in Fig. 1. Note that this bank of transformers serves two other motors, one a 440-v., 3-phase, 25-hp.; the other a 220-v., 3-phase, 10-hp.

Our electrical department first heard of this trouble when it was informed that the compression machine motor was running hot and blowing fuses. The motor was dismantled, tested, cleaned and inspected for low bearings, grounds, shorts, etc. but nothing was located. The motor was replaced and started but it soon blew another fuse.

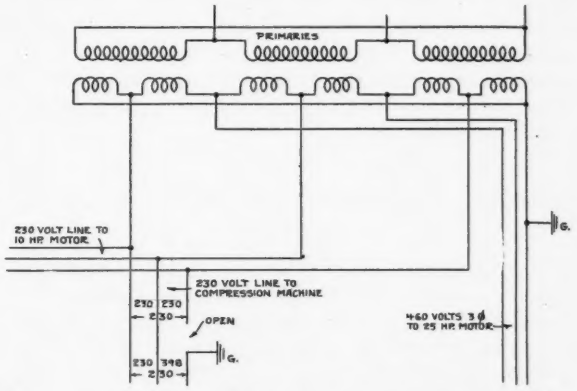


FIG. 2. SAME DIAGRAM AS FIG. 1 BUT SHOWING LOCATION OF "GROUNDS," AND "OPEN"

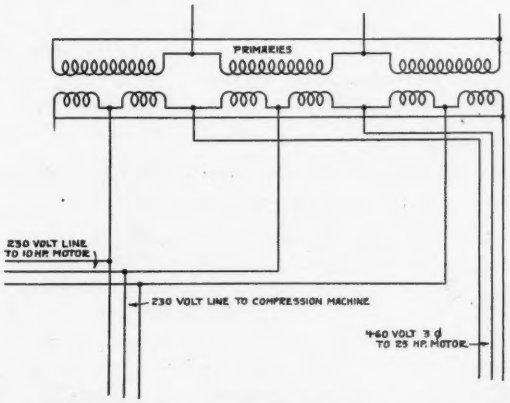


FIG. 1. WIRING DIAGRAM SHOWING TRANSFORMER CONNECTIONS

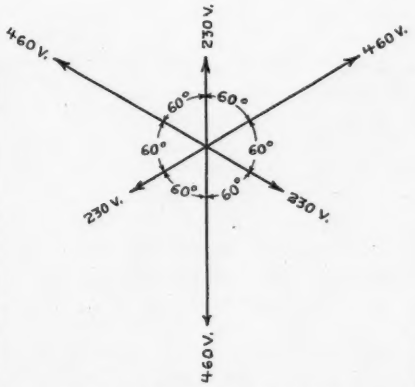


FIG. 3. NORMAL VOLTAGES AND PHASE RELATIONS

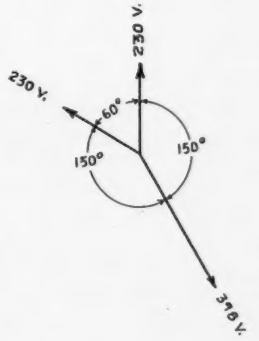


FIG. 4. VOLTAGES AND PHASE RELATIONS ON THE 230-V. CIRCUIT, DUE TO "GROUNDS" AND "OPEN"

A second man of more experience was sent to the job at this time, as no headway was being made in finding the trouble. After a trial or two, he came to the conclusion that the trouble was due to overload caused by the worm on the motor shaft slipping endways, thus causing a bind; this was tightened, the motor started and a pressure of 200,000 lb. raised on the compression machine, everything being apparently all right. Soon, however, after this repair man had left, another fuse blew and the man was returned to the job. He tried the motor idle and found that it still blew fuses but he also noticed it was the same fuse each time that went out first, which indicated to him something wrong with one of the motor windings. Upon removal to the repair shop for test and repair, however, the foreman was informed as to the action of the motor in blowing one fuse first and he at once decided that the trouble was probably external to the motor. On this assumption, a test lamp was used to test across each of the three phases at the motor switch; this test indicated normal voltage on two phases with considerable over-voltage on the third phase, which was the one on which the fuse blew first.

As there had been some severe lightning, the first thought was that a transformer had broken down but upon test with a test lamp at the transformers, all phases had their proper voltage; a second test was made at the 220-v., 10-hp. motor, Fig. 1, and again all phases were equal. A third test was made at the switch of the motor

in trouble and the phases were found to be still unbalanced. To determine actually how much, a voltmeter was used at the latter place and it was found that two phases had a potential of about 230 v. while the other had about 398 v. After some study, a clue as to what might be wrong was discovered when it was noticed that the over-voltage was approximately 1.73 times the voltage on the other two phases and 86.6 per cent of 460 v., which was the potential of the other three-phase connection to these transformers, as shown in Fig. 1. Having previously tested the transformers for breakdown and found them O.K., the natural assumption was a ground, which proved to be correct, as shown in Fig. 2, which also shows why the over-voltage was indicated at the one point on the 230-v. system. The point of ground of switch wire and the open of line wire to the switch was located in a conduit and was evidently caused by lightning. A study of Fig. 3 and 4 will show the voltages and phase relations involved, Fig. 3 showing the normal voltages and phase relations. Figure 4 shows the voltages and phase relations at compression machine motor while the abnormal condition existed.

Proper Drilling Necessary in Crack Repairs

MR. HITZE, on page 1053 of the Oct. 1 issue explains how he tried the plan of drilling and plugging holes at the ends of a crack in an endeavor to prevent the crack extending, but without success. Probably the holes were not made at the extreme ends of the crack.

When such a defect occurs, the ends of the crack usually extend anywhere from 2 to 4 in. farther than is visible to the eye. To mark this fine extension, light oil should be rubbed into the crack along each end and the surplus oil wiped from the surface; then a little fine chalk dust should be rubbed over the ends of the crack. The oil in the invisible extension of the crack will penetrate and show through the chalk; then the holes should be drilled and plugged at the extreme ends of the crack as shown by the oil.

If Mr. Hitze had used a good iron cement in the V-shaped hollow he chipped out and a soft patch of boiler plate or a properly made and applied holding band to retain the cement in place, the chances are he would have succeeded in checking both leak and crack. So far as I know, there is no iron cement sold that would hold over such a crack without the addition of some kind of a backing. As Mr. Hitze had 1¼ in. thick iron to work on, a half inch thick boiler plate large enough to cover the defective part fully, could have been rolled to fit the heater and strongly bolted in place with ⅝-in. bolts, having a suitable packing under the patch.

Mr. Hitze was lucky in his use of ordinary rubber cement. When such a cement is placed on a smooth iron surface, it usually curls and peels off after a few minutes when it has dried. It is my opinion that a ½ in. thick iron plate extending for some inches at each side of the crack and properly bolted to the heater would have a much better chance of preventing the crack extending than does the elaborate repair used by Mr. Hitze.

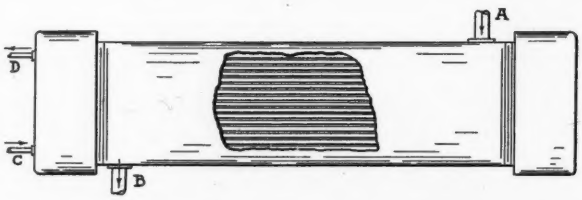
I am not in favor of using a rubber packing on such a job. A high grade iron cement can now be obtained which will work much better. It can be used as either a quick or slow drier or hardener as its expansion is the same as iron. It will hold against any pressure and it does not deteriorate as will rubber when exposed to a constant heat.

Toronto, Canada. JAMES ELLETHORN.

Heat Exchanger Saves Fuel and Water

WHERE LARGE HEATING plants are installed such as in office buildings, hotels and public institutions, the simple but effective heat exchanger described will show a substantial saving of fuel and water. It will also improve the heating system by making it possible to maintain a high vacuum. One of these installed in the Kansas State School for the Blind at Kansas City, carries a vacuum of from 9 to 10 in. at all times without use of injection water.

This heat exchanger may be made of a pipe of 12 to 20 in. diameter or of boiler plate. The condensate should enter the top at A as shown in illustration and discharge at the bottom at B. The discharge should be



LARGE PIPE FITTED WITH A COIL SERVES AS HEAT EXCHANGER

lower than the opposite end in order to provide for proper flow of condensate. Cold water enters the coil at the bottom at C and discharges at the top at D. The coil, which should be made of 1¼ or 1½-in. pipe, should fill the shell as completely as possible.

Kansas City, Kansas. J. F. STALEY.

Economies of Combining Industrial Power Plants

REFERRING TO the discussion by Mr. Rogers in the July 1 issue, of my article in the May 15 issue, the case presented in my article was assumed but based on a study recently made of a quite similar condition. The findings in this case took into account many conditions found in the study of the actual plants but which were omitted from the article to avoid too great detail.

The comments are well taken, if the cheapest possible plant is desired. On the other hand, none of the three alternate schemes he proposes would allow any spare boiler capacity and the writer's experience is that, for plants of the type represented by C, at least one spare unit is imperative and, if the boilers are set two in a battery, two spare units are highly desirable. If a new plant were being designed for the load described in the article, three 300-hp. boilers set singly and stokered to operate up to 300 per cent rating would probably have been chosen but the case considered was based on utilizing present equipment and keeping the new equipment of such a type as to match, as well as possible, with present equipment.

Mr. Rogers doubts the workability of a theoretical

division of costs and suggests charges for steam and electric power, determined by agreement, which will give a surplus to the power house,—then dividing this surplus in proportion to the several investments. No suggestion as to how the charges shall be determined or the several investments apportioned is given.

Proper division of costs and apportionment of investments is always one of the most difficult parts of such a problem, whether it be between associated industries or different departments of the same plant. The writer's experience has been that a division based on a careful analysis of services rendered is always more equitable and more satisfactory than any hit or miss distribution arrived at by agreement. The method of analysis and division given in my article was not intended as a hard and fast rule but rather as a suggested method of attack which could be modified as found desirable to fit any specific case.

Hamden, Conn. WM. W. GAYLORD.

Air Compressor Operation

READINGS ON THE pressure gages between stages of an air compressor provide a good indication of the condition of the piston rings and valves, if the various readings are noted and recorded when the compressor is known to be in first class condition, and these readings compared with those obtained during continuous running. Any great difference in the readings will indicate leaky valves or piston rings.

Abnormal pressure rise in the high-pressure stage would probably be caused by some obstruction in the pipe line beyond the compressor such as clogged spray valves, when used in connection with a Diesel oil engine, and a drop in pressure may be caused by a spray valve sticking open. The purge pots situated between stages should be kept well drained; the frequency with which the cock should be opened will depend largely upon the atmospheric conditions. Once an hour should be sufficient but water must not be allowed to collect, otherwise there is a risk of its being carried over by the rushing air and into the engine where it will lead to misfiring.

CAUSES OF WEAR

In one case, there was considerable trouble with the abnormal wear in the intermediate-pressure and high-pressure stages of a compressor, the valves and piston rings being scored by some abrasive substance. The source of trouble was finally traced to the low-pressure purge pot, which had iron parts that had rusted through the accumulation of water. Particles of this rust were carried forward with the air and did the damage mentioned. When the defective purge pot had been cleaned and varnished inside, the trouble ceased.

Intercooler coils of compressors are liable to burst. These tubes wear internally, owing to the air passing through them at high velocities. If the air contains grit, the wear will be greatly increased, especially at the bends; hence it is advisable to filter the air before it enters the compressor. The coils gradually weaken due to mechanical erosion and the corrosion caused by the presence of acids developed from the lubricant fed to the compressor, and carried forward with the air.

Compressors should be oiled sparingly with a good grade of compressor oil. If an excess of lubricant is fed to the compressor, part of this will be carried with the air into the coils, where, under the high temperatures prevailing, it will quickly develop acidity and form a carbonaceous mass on the pipes. This will lead to inefficient cooling of the air and, as the carbon will be heated to the air temperature, in many cases approaching red heat, under the right circumstances, this will be sufficient to ignite any oil vapor in the air. It may lead to an explosion.

The necessary temperature to ignite oil vapor is not well defined; experiments have proved that, due to decomposition of the oil, gases may be formed which can be ignited at very low temperature. Provision of air safety valves in the piping is largely useless in such cases, as the pressure rise is too sudden for them to act. If there is little oil vapor, the explosion may do no harm but, if there is a considerable quantity, the coil may burst.

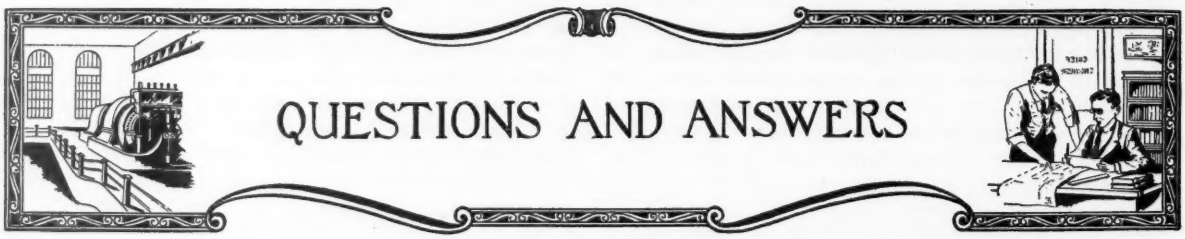
Examination of a certain intercooler coil revealed that for the first one third of its length the tube was coated with carbon, gradually giving way to a coating of green deposit which was thickest at the far end of the tube. The tube had been slightly worn by mechanical abrasion and was also wasted due to chemical action. This wasting was greatest at the middle of the tube and least at the far end where the green deposit was thickest.

Carbon coating was due to the lubricating oil which was carbonized by the heat of the coils; the green deposit was due to the moisture and the wear seems to be accounted for as follows. Damage begins only after the air has traveled sufficiently far along the tube to become cooled so as to throw out the moisture held in suspension. The water is then released in a mist, which attaches to the walls of the tubes, eroding particles of metal which are carried forward by the air and doing further damage along the tube. In the last part of the tube, the moisture forms a thin skin on the tube, shielding it from further action. The coating of carbon near the entrance of the tube largely shields it from erosive action but there is wasting due to corrosion by acidity in the oily carbon. The carbon collects thickest at bends and obstructions. Throttling the air flow allows projecting accumulations of carbon to be formed, which will be heated to a high temperature by the velocity and temperature of the air.

The amount of wear may be judged in two ways; the coil may be removed and tapped with a small hammer. If it can be dented at any place, it should be replaced. With experience, sound provides a good guide as to the metal thickness. Another method is by weighing. The coils are weighed periodically and, when the weight has fallen 20 per cent below its original value, the coil is discarded. Before weighing, all deposit should be removed from the tube. By reducing the supply of lubricant to a minimum and by insuring that the air contains a minimum of solid impurities, the life of these tubes should be prolonged.

Brentford, England. W. E. WARNER.

MODERN SOCIETIES now fight Nature less and use her more. They throw her energies and theirs into one rhythm. Man allies himself with Nature and finds new powers.—Baker Brownell.



Nonreturn Valve Installation

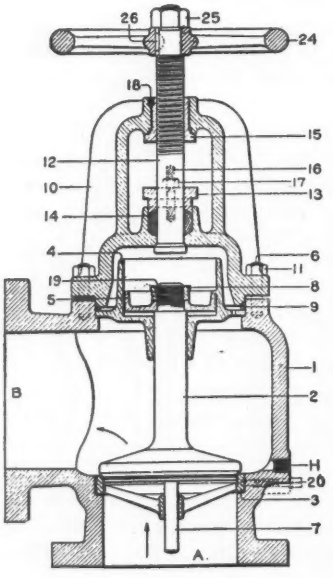
I WOULD greatly appreciate information regarding the following:

1. Where is a nonreturn stop valve placed on a boiler?

2. What is the construction of a nonreturn stop valve?

3. At what pressure does a pilot valve in connection with a nonreturn valve open and why is it used?

4. What is a bleeder and where is it connected?



NAMES OF PARTS

1	Body
2	Clapper
3	Seat ring
4	Dash-pot
5	Dash-pot piston
6	Body studs
7	Tail-piece
8	Clapper nut
9	Copper gasket
10	Yoke
11	Body stud nuts
12	Stem
13	Stuffing box gland
14	Packing
15	Yoke nut
16	Stuffing box studs
17	Stuffing box stud nuts
18	Yoke Nut Retaining Screw
19	Clapper Nut Retaining Screw
20	Seat-ring Retaining Screw
24	Hand wheel
25	Stem nut
26	Hand wheel key
A	Inlet
B	Outlet
H	Drain

FIG. 1. AUTOMATIC NONRETURN STOP VALVE ACTS AS EQUALIZING AND SAFETY VALVE

5. At what pressure should the bleeder be opened and how long should it remain open?

6. What size pipe is used for bleeders and are globe or gate valves used?

7. At what pressure should a boiler be cut in with other boilers?

8. What should be done if the nonreturn valve sticks to its seat?

9. If the pressure on a boiler is 100 lb., at what pressure does the nonreturn valve open and when does it close?

10. What are the advantages and disadvantages of a nonreturn valve? J. M.

A. Nonreturn stop valves are placed on the top of the boiler. The A. S. M. E. Boiler Code has the following specification regarding installation of stop valves:

"When two or more boilers, having manhole openings, are connected to a common steam main, two stop valves, with an ample free-blow drain between them, shall be placed in the steam connection between each boiler and the steam main. The discharge of this drain valve must be visible to the operator while manipulating the valve. The stop valves shall consist preferably of one automatic nonreturn valve (set next the boiler)

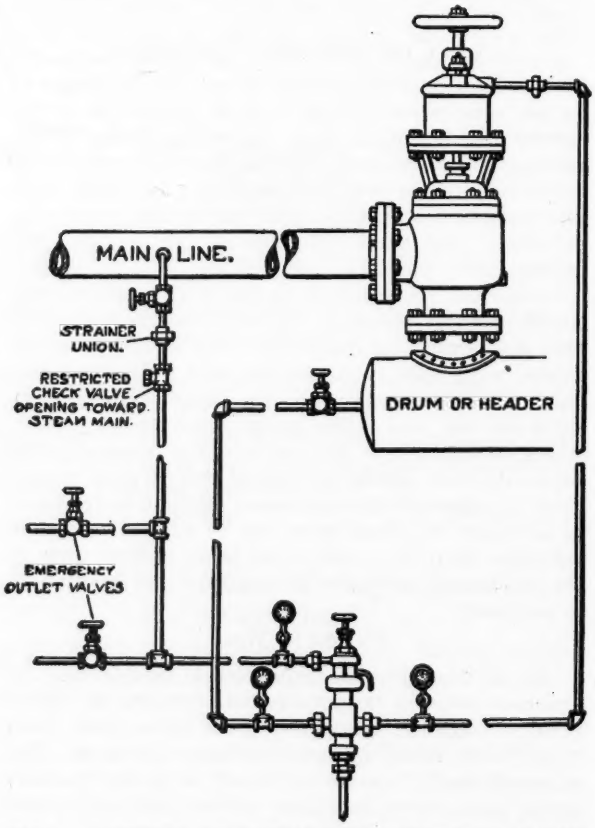


FIG. 2. METHOD OF INSTALLING NONRETURN VALVE SHOWING PIPING ARRANGEMENT OF PILOT VALVE WITH MAIN VALVE AND METHOD OF OPERATION

and a second valve of the outside-screw-and-yoke type; or, two valves of the outside screw-and-yoke type, may be used.

Automatic nonreturn valves stop a flow of steam from the main header into the boiler in case of rupture of any part of the boiler. They also automatically cut the boiler in and out of service. When the pressure in the boiler becomes as great as that in the main header, the valve opens automatically.

2. Figure 1, which is self-explanatory, shows the construction of the nonreturn stop valve and Fig. 2

the method of installation in connection with a pilot valve.

3. Pilot valves, whose function was to balance the pressure, are little used now.

4. A bleeder, or drain valve, as it is more properly called, is placed between the two stop valves to prevent any water from collecting there and causing water hammer if one of the stop valves is suddenly opened.

5. The time of operation of the drain valve is not governed by pressure. It should be open at all times when water would otherwise collect between the stop valves and it should stay open until water is removed.

6. A ½-in. pipe is usually used for the drain and either globe or gate valves may be used.

7. The pressure on the boiler that is to be cut in should be the same or a little above that of the header. It should be not more than 4 or 5 lb. above the header pressure.

8. If dirt goes over, a nonreturn valve may stick on its seat. When this occurs, the boiler should be closed down and the valve cleaned and, if necessary, repaired.

9. Referring to Fig. 1, inlet A is connected to the boiler nozzle and outlet B to the header. When the pressure at A is about 1 lb. greater than the pressure at B, valve 2 lifts and is held open by the flow of steam passing through the valve. If the pressure at A should fall below that at B, due to the blowing out or rupture of a tube, a cock blowing off or from other cause, the back flow of steam from B, acting on the upper side of clapper 2, plus its weight, automatically forces the valve to its seat. The clapper is then held to its seat until pressure at A rises above pressure at B.

For 100 lb., the pressure necessary to open the valve must be enough over that to overcome the weight of the valve clapper; closing will take place when boiler pressure falls to 100 lb.

10. The advantage of installing an automatic nonreturn valve is that in case of accident, the valve closes as soon as the pressure drops, preventing the one boiler from draining steam from the balance of the boilers.

Corliss Engine Operation

REFERRING to the questions by M. L. S. on page 1013 of the Sept. 15 issue, I believe the fluctuation of speed in long or short stroke engines when load is thrown off varies little due to length of stroke. If the governor is sensitive, any sudden increase of speed would cause the knock-off cams to keep the valve from hooking up and the only chance the engine would have to race would be due to the steam left in the cylinder at the time the load was thrown off, although a lunge may occur after the flywheel has carried the engine over center. Of all governors, a Corliss engine governor comes nearer having full control, regardless of stroke, than any other type I have ever handled.

Regarding the extra precaution to be considered in setting valves of a long stroke Corliss engine, the length of the cutoff is proportionate to the load handled by the engine and for maximum economy but the main point is to watch the angularity of the connecting rod as this angularity will vary more in a long-stroke engine than in one of short stroke and this affects the equalization of steam distribution.

In starting a cross-compound engine, it should first be warmed. The only bleeder to look out for on a Corliss engine is the little bleeder on the main steam line at the throttle valve. Sometimes warming lines are provided; at other times, you must warm the cylinder through the throttle valve but all drips in the exhaust lines are trapped so that consideration does not have to be given them by the operator.

When the engine has become hot, the circulating water, then vacuum pump should be started. If you have a live steam bypass to the receiver, crack the valve and allow the receiver pressure to build up to from 10 to 15 lb. Then work the condensate out of both cylinders, if the hook rod is of the detachable type. If it is not of that type, crack the throttle and pick up the valve at either side so as to admit steam to the cylinder in the direction in which the engine is to turn and the water which happens to be present will be taken care of by the vacuum pump, if the engine is be taken care of by the vacuum pump.

This rule will hold good with either an overhead receiver or one that is submerged, as steam traps are provided, at all times, to bleed the water from the receiver. So, by building up the receiver pressure before starting the engine and allowing the low side to warm up, the traps are caused to operate and the receiver and steam lines between the cylinders are cleared.

Los Angeles, Calif. H. A. CRESEY.

Sulphur Aids in Drilling Iron

IS THERE any way to soften small castings made of cast iron so that they will machine more easily?

C. W. F.

A. We presume that these have been "chilled," as is frequently the case with small cast-iron castings, due to dampness of the mold at the time of pouring the iron and the thinness of the metal, the mass of which is so small that it can not dry out the mold before it hardens.

Surfaces so chilled may be softened by burning sulphur on them. If sufficient softening is not obtained at the first application, one or more subsequent applications should be made. This material may be obtained from your druggist in the form of "flour of sulphur." A small quantity of the sulphur is placed over the part to be machined and lighted with a match.

If the required machining consists only of drilling small holes in the metal, softening is not needed. A small drill, whose tip end has been hardened by dipping it at a "cherry red" heat into mercury, will easily drill chilled iron or even glass. Only the tip should be dipped, as the mercury causes the part dipped to become extremely hard and brittle.

Magnesia Tile Serves Well as Blowoff Pipe Covering

WE ARE bothered with the burning off of the blowoff pipe covering. Can you give me some information regarding coverings for blowoff pipes? C. M.

A. An excellent blowoff pipe covering consists of split magnesia tile. After placing this tile on the pipe, it is held together temporarily by wire and cemented at the joints.

EDITORIAL COMMENT

Plant Economy Is a Result of Personnel Development

Looking at the advancement in the economy of power production during the past decade, the tendency is to forget the part played by the men who, minute by minute, keep tab on plant operating conditions and make adjustments, as changing tendencies direct, to maintain the ideal relations among the various units of the plant.

Nobody questions the fact that modern plant equipment is more efficient than that of 10 yr. ago; nor is there any question that interconnection has resulted in more favorable load factors and consequent economies. Automatic operating features and instruments, too, have performed a wonderful service in reducing power costs; but without intelligent men in charge of these wonderfully equipped plants, efficiency would still be low and economy would suffer accordingly.

What has taken place during the period over which the coal consumption has been reduced from an average of 5 lb. per kw-hr. to less than 2 lb. has been a development not only of machinery but of power plant personnel. This development has taken a long time. Almost a complete generation has been occupied first in convincing the owners of power plants that real science as well as skill is required to operate their plants, then in training and educating operators sufficiently to get the most out of the equipment under their care.

Science and invention are far ahead of commercial demands in this field of industry. Scientists in laboratories are experimenting with newly discovered principles that they are confident can be made to increase efficiency. To employ these principles economically involves a sufficient demand to make manufacturing profitable. In creating this demand, the scientists must first educate those responsible for the selection and operation of new equipment to the advantages to be gained by employment of the new principles.

Naturally, considerable pioneering must be done which only the courageous will undertake, others will follow if the first applications are successful. Thus we find that advancement takes place no more rapidly than the industry is able to train men into successful users of advanced ideas and here is where the plant operating force holds the key to power plant development and economy. The mere coal passer as a fireman and the throttle twister as an engineer have been eliminated from modern power plants and in their places have come serious-minded men, well versed in the practical application of physics and chemistry to their particular work in the plant, with minds trained to recognize the significance of changes in conditions and how to meet them.

This development in power plant personnel is, we believe, one of the principal causes of reduction in fuel consumption and the plants that have recognized this fact are now reaping the benefits of their efforts to develop men as well as machinery, in greater economy throughout the entire plant, lower accident rates, more definite assurance of continuous operation and less labor troubles.

Rural Electrification

Extension of electric service to the American farm, a task that a few years ago seemed to present insurmountable difficulties and call for huge financial investments with little promise of reasonable returns, is now a fact. The electrical industry, farmers, colleges, manufacturers and government departments have been moving harmoniously forward to a point beyond the dreams of the most enthusiastic advocate of a few years ago.

The recent report of the National Committee on the Relation of Electricity to Agriculture contains under one cover, in some 136 pages, all known information on this subject. It is a composite picture of accomplishment in 24 states during the past 4 yr., a guide for the future and a record of the past.

Progress must be based on mutual satisfaction to both parties and this can be accomplished only by intelligent load building, that is, the application of electricity in such a way as to promote energy consumption so as to cut labor costs and increase farm production.

One of the biggest problems is to acquaint the farmer with the possibilities of electricity and bring to him the realization that electricity, in addition to illumination, is applicable to some 200 different farm services. This problem is not discouraging; the farmer is not backward or hesitant to learn but, busily engaged in making a living in a period that is none too prosperous for many of them, they are not in a position to keep pace with rapid development unless such development is specifically called to their attention and the possibilities demonstrated.

Rural electric service departments in many utility companies are carrying this work forward. Creation of such a department is no longer an adventure but is regarded as the one logical and sensible way to meet the problem.

Illinois Commerce Commission reports indicate a considerable reduction in the cost estimates of transmission lines and show that utilities sincerely desiring to develop this business feel satisfied that they can build lines at from $900 to $1100 a mile. They also state that the Commission has accepted for filing rates, of the service charge type, in which the minimum bill for a 3-kv-a. or smaller transformer is $10 a month, this minimum including 135 kw-hr., after which the charge is 3 cents per kw-hr. The utility finances the lines to the extent of $450 per customer. In general, the serv-

ice charge rate appears to be favored, especially in the middle west.

Except for the ever-present pressure of lower construction costs, the engineering problems of this phase of the industry are not bothersome and the continued growth of this farm load evidently depends largely upon the growth and development of an efficient Rural Electrification Department in each of the various utility organizations, the personnel of which should be thoroughly conversant with all phases of both utility and agricultural requirements.

Turbines as Steam Meters

Metering hot condensate is a pernickety job. Hot-water meters require careful attention to insure accuracy and evaporation losses are difficult to eliminate.

Electric motors, whose efficiency at various outputs has been tested, are frequently used to measure delivered power. Steam turbines, whose steam consumption at various loads has been tested and charted can similarly be utilized as meters of steam. At Padiham station, this method has been followed, the load on a turbine-generator unit being metered and steam consumption taken from the chart. Check is made of steam consumption each month by testing at three loads over a 2-hr. period and measuring condensate with a V-notch Lea recorder. Corrections are made for variations in vacuum or steam conditions and condensate is tested each day for condensate leakage by comparison of its electrical resistance with that of distilled water.

As the Williams line, or relation between total load and total steam used is usually practically straight, variations in load have little, if any, effect on steam consumption metered by this method. Results have been easily obtained and check well against probable boiler and turbine efficiencies.

Auxiliary reciprocating engines and boiler feed pumps have likewise been tested and used as steam meters but the factors which may bring in errors with these steam users seem more complex and likely to affect the record than in the case of steam turbines.

Where steam flow-meters cannot be had, it would seem that the turbines may readily be utilized in the method outlined as at least a check on boiler plant performance.

Scrap-Pile vs. Manufactured Equipment

Development by operating engineers of needed apparatus out of scrap or otherwise discarded parts in order to overcome difficulties in operation or provide means for better performance, exhibits ingenuity and is always interesting but it is sometimes difficult to understand why such procedure is permitted to be so common when so much information regarding costs and applications of devices, specially designed to overcome such difficulties, is available.

Resistance to change may exist under some conditions, such as may occur in large organizations, due to red tape or to the inertia that must be overcome in order to have due consideration given to a proposed plant betterment; but in smaller plants where the contact between the power plant force and the financial backers of the organization is closer and more intimate, this difficulty should be less pronounced.

Large organizations, however, are awakening to the fact that much is to be gained by employing alert, well-trained engineers and not only giving them authority to purchase, under the budget plan, what improved apparatus they may determine is necessary but also giving them sufficient time not only to keep well informed in their line, including opportunity from time to time to visit other outstanding power plants, but also sufficient freedom from routine duties to permit them to develop betterments.

Industrial power plants suffer, perhaps, worst of all because of difficulty in obtaining proper support in betterment projects. This is doubtless due to several causes. The proprietor of a factory is more interested and better versed in the manufacture of the product of his factory than he is in the production of power and rarely looks upon power and heat, although he may produce them for his own consumption, as a product of his factory, hence he does not give that phase of production the same intelligent business consideration that he devotes to his factory processes.

Doubtless the factory manager considers that the same power plant force would be in many cases required after introduction of certain devices that are employed before their introduction. He feels that he has an irreducible minimum of help or he may feel that his present power plant force has time enough on its hands not only to devise necessary contrivances but also to construct them, hence the engineers are compelled to resort to the scrap pile. But is this sound deduction? Does not experience show that when reliable men are in charge, a power plant is operated most efficiently when the chief engineer has sufficient freedom from routine necessity to permit him not only to delve into the problem of perfecting his apparatus, but also of improving his management of the plant by adequate study of properly kept records?

Among the other factors that contribute to this complacent attitude of conservatism held by some factory proprietors toward power plant improvement is that of skepticism toward the too inclusive claims frequently advanced by over-enthusiastic salesmen who are ever ready to claim superiority for their device under all conditions of operation. After all, is not such skepticism frequently justified?

It is believed that greater confidence is secured by a manufacturer of power plant equipment when his agents are willing to concede better adaption of a competitor's product under certain conditions of service than they would claim for their own product.

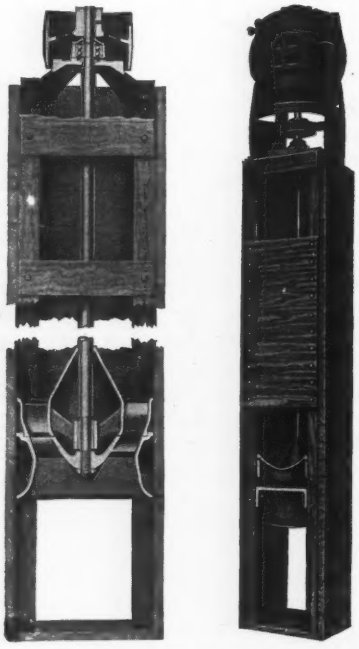
It would seem to be highly profitable for factory managers, who furnish their own power, to consider power as one of the products of their organization and to exercise equal business sagacity when considering it. It would seem to be equally profitable for manufacturers of power plant equipment to withhold advocacy of the merits of their product for a given condition of service until they had proven conclusively that their claims were warranted.

Many equipment manufacturers earnestly refrain from overzealous statements but the whole field is detrimentally effected by such statements made by less scrupulous salesmen.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Screw Pump for Low Heads

RECENTLY development in pumping equipment has been made for handling large volumes of water at low head. A self-contained vertical screw pump unit has just been announced by Fairbanks, Morse & Co., designed mainly for irrigation and drainage service, but suitable for any type of pumping where the head



EVERGLADES SCREW PUMPS DESIGNED FOR BELT AND MOTOR DRIVE

is not over 8 ft. and a low-cost installation is desired. It is called the Everglades screw pump.

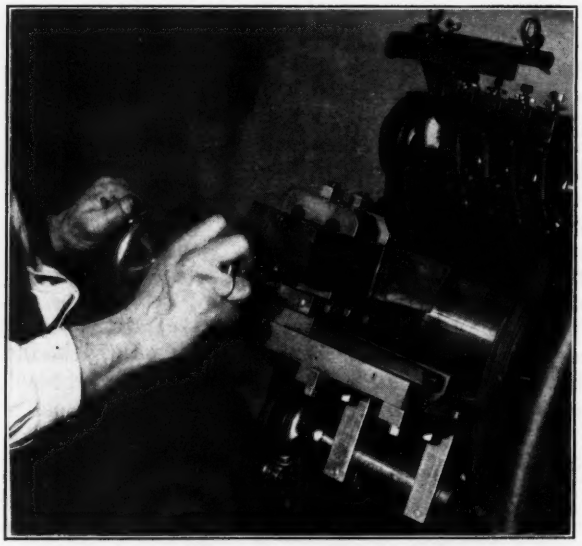
This machine consists of cast-iron spiders, carrying a Wood screw-type impeller and diffuser. Four wooden corner posts are fastened to the spider and the structure boarded up so that it may be placed vertically in a ditch or stream and arranged to discharge over the top of a levee, or embankment. Using a wooden box construction for the casing makes it easy to adjust the amount of lift or change the position of openings. On two opposite sides of the box boards are permanently fastened to the frame posts but boards on the other two sides can be arranged to suit different operating conditions, or removed from the discharge side, less than 8 ft. head is needed. The pump thus operates with a minimum amount of power.

Only a 24-in. size is manufactured. The inside dimensions of the box, are 25 in. square by 12 ft. high, with 4 by 4-in. corner posts. The intake opening is 17 by 28½ in., while the discharge opening is 17 by 18 in., although the latter can be adjusted to suit requirements by removing or replacing side boards.

Drive is by direct connection to vertical motors, belt drive from motors or internal combustion engines, using ¼ twist belt, or by means of a gear box, which may be provided at the top of the pump. When driven by a 720-r.p.m., 25-hp. motor, this pump will deliver 7200 g.p.m. against an 8-ft. head.

Tool Rest for Commutator Resurfacers

DESIGNED for use in conjunction with Ideal commutator resurfacers, the Perfect tool rest, a portable grinder, has recently been placed on the market. This tool rest is installed and used as shown in the



IDEAL TOOL REST IN USE

accompanying illustration. It has been designed especially for removal of long flat spots and eccentricities in commutators and is attached to the machine so that the work can be done with the motor armature rotating in its own bearings and at its normal speed.

This tool rest, which is portable, is made with base from 6 in. to 28 in. long, varying by 2-in. steps. Those 14 in. or less have two supports while those longer than 16 in. have three supports. Supports are either L or T shape, for round or flat brush arms. Cross feed is by a large hand wheel, as shown, while a screw infeed adjustment is provided. The rest is designed to take a

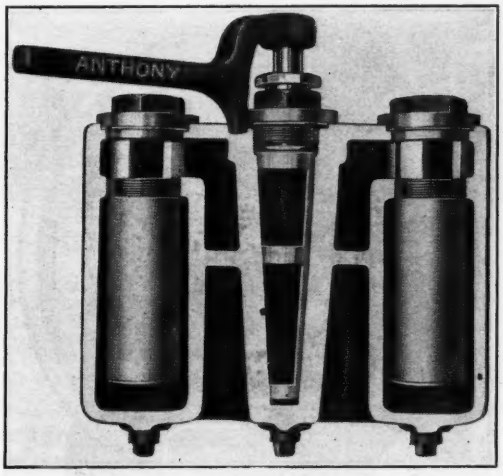
cutting stone of 2-in. by 2-in. face or smaller, of any length. It is made by the Ideal Commutator Dresser Co., Sycamore, Ill.

Strainers for Pipe Lines

STRAINERS for use in pipe lines carrying fuel oil and other liquids are now available in the form shown, designed to be cleaned without removal. This is a duplex unit but single strainers are also furnished. Bodies are made of ferro-steel and baskets of perforated sheet brass, unless otherwise specified. Each strainer is tested for use at 500 lb. liquid pressure and 250 lb. working steam pressure.

Duplex strainers designed especially for oil burning systems, consist of two chambers in one body, the flow of liquid being controlled through either by one cock. Direction of flow is from outside to inside. Sediment collecting in the reservoirs around the baskets is removed through a drain in the bottom. This sediment is blown out by steam, compressed air or water, through a line connected to the top of the strainer body. This purging fluid enters the inside of the basket when out of service, blowing out the sediment in the reverse direction to normal flow.

Both single and duplex strainers in ½-in., 2-in. and



DUPLEX STRAINER SHOWING BASKETS AND CONTROL COCK

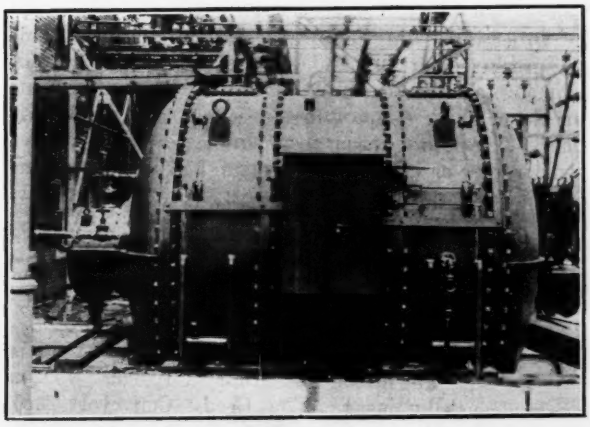
4-in. sizes, have recently been put on the market by The Anthony Co., Long Island City, New York. Baskets can be furnished with any commercial mesh but the regular stock sizes are No. 00 and No. 4 for the ½-in. size and 1/64 in., 1/32 in. and 1/16 in. for the larger sizes.

New Hydrogen Cooling System for Electrical Equipment

UP TO 50 per cent more power can be handled by the same size electrical apparatus equipped with a new system of cooling, it is claimed by the General Electric Co. Use of hydrogen gas within a totally-enclosed rotating machine has made possible this increase in capacity, it is stated, without increasing the operating temperature beyond the point of safety and it is the temperature that has limited the load which can be carried.

First commercial application of the new system of hydrogen cooling has been made with a synchronous condenser installed by the New England Power Co. at its Pawtucket, R. I., substation, as shown herewith. If the condenser were air-cooled, its capacity would be 10,000 kv-a. but by having it hydrogen-cooled, its capacity has been increased to 12,500 kv-a. With hydrogen at 15 lb. per sq. in. gage pressure, the machine could deliver 15,000 kv-a. without exceeding the normal temperature guarantees, according to General Electric engineers.

Advantages claimed for hydrogen cooling are that capacity is increased for a given size of machine, oxygen and dirt are excluded by the air-tight casing, hydrogen will not support combustion, therefore fires of any kind —even from short circuits—are impossible. Hydrogen also eliminates the effect of corona on the insulation, it is stated. The hydrogen-cooled equipment, being totally



OUTDOOR HYDROGEN-COOLED SYNCHRONOUS CONDENSER AT PAWTUCKET

enclosed can be placed outdoors, with a resultant saving in building cost. The Pawtucket condenser is outside the substation. Hydrogen is much lighter than air, and the wind resistance loss is reduced to about 10 per cent of the loss in air when hydrogen at atmospheric pressure is used.

At Pawtucket, the synchronous condenser is enclosed in a gas-tight explosion-proof cylinder, consisting of three main sections bolted together and provided with end bells. An extension on one end of the casing encloses the slip-ring mechanism. A carbon seal is placed around the shaft where it enters this housing, so that the brushes may be adjusted or replaced without losing hydrogen from the main shell. The bearings are supported by structural steel frameworks welded to the inside of the casing.

Heat absorbed by the hydrogen is removed by four internal surface-type coolers, consisting of nests of pipes arranged concentrically inside the shell and close to each end of the casing. Hydrogen is drawn in along the field structure by fans placed at the ends of the shaft and is forced radially outward through ducts in the armature laminations. It then passes back along the inside of the shell to the coolers, after which it is again

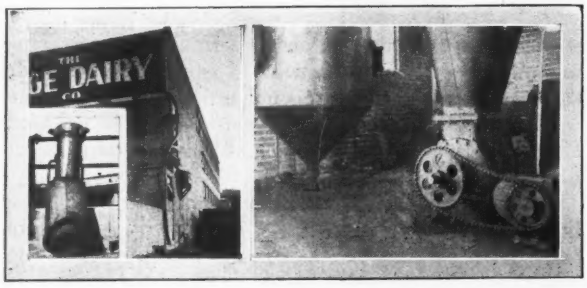
drawn into the machine by the fans and recirculated. The cooler pipes are supplied with circulating water from the substation mains.

Full automatic operation is used with the condenser. A pressure-regulating switch and valve maintain the hydrogen pressure sufficient above atmospheric pressure so that leakage, if any, will be outward, thus preventing the contamination of the gas by air. A recorder in a cabinet attached to the casing gives a continuation indication of the purity of the gas, and operates an alarm if the purity of the gas falls below 91 per cent. The condenser is kept so tight that the loss of gas is negligible, the replacement cost amounting to less than seven cents a day. The loss is made up by hydrogen that is automatically drawn from a commercial bottle of the gas connected to the piping system. Since a hydrogen and air mixture containing more than 70 per cent of hydrogen by volume is non-inflammable, there is an ample factor of safety against ignition of the cooling medium. As an added precaution, however, the casing is strong enough to withstand the disruptive force of the most explosive mixture of hydrogen and air.

Other interesting features of the installation include oil pressure starting, and the use of indicating thermometers on the bearings. These thermometers operate an alarm if the temperature exceeds 60 deg. C., or 140 deg. F. Another thermometer indicates the hydrogen temperature as it leaves the coolers, and rings an alarm if this temperature exceeds 40 deg. C., or 104 deg. F.

Pneumatic Coal Conveyor for Industrial Plant

UNLOADING AND transporting of coal for the power plant of the Page Dairy Co., Toledo, O., is accomplished by means of a Brady Conveyor Corp. pneumatic coal conveyor.



SEVERAL VIEWS OF THE INSTALLATION AND EQUIPMENT AT THE PAGE DAIRY CO.

At this plant, hand-fired horizontal return tubular boilers are installed, the boiler room being located some 75 or 80 ft. from the railroad siding with a large warehouse intervening. Up to a few months ago, coal was received by auto truck.

Recently the pneumatic system was installed. This system consists of a motor driven exhauster, a cyclone, motor driven feeder for delivering the coal from the bottom of the cyclone to the coal bunker, an air washer or scrubber and a suitable length of flexible steel hose with a specially designed nozzle, shown in Fig. 1.

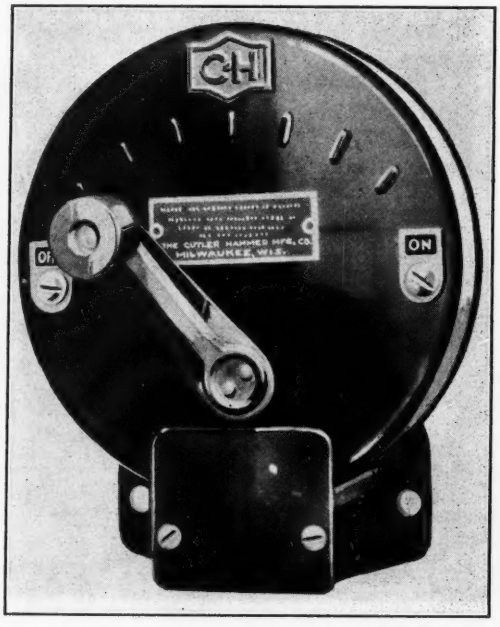
By means of a suitable joint and swinging bracket or boom, the flexible hose with the nozzle attached can be made to reach any part of a properly located coal car. From the unloading point, the coal is carried through a pipe to the cyclone located in the penthouse above the coal bunker.

Coal and air, entering the cyclone, are separated by centrifugal action, the coal falling to the bottom, where it is fed by the feeder, shown at the right-hand side of the photograph, to the bunker below and the air, leaving the top of the cyclone, passes through the washer or scrubber shown at the left of the feeder to a Roots exhauster driven by a 50-hp. motor.

Under average conditions, a 50-t. car of slack can be unloaded in 3 hr., with a power consumption of 42 hp., or of somewhat less than 3 hp. per ton. A suction of 7 to 10 in. of mercury is maintained at the exhauster.

Regulating Rheostat for Small Direct-Current Applications

NEAT APPEARANCE and simplicity of installing are stated to be the features of a new direct-current, regulating rheostat announced by The Cutler-Hammer Mfg. Co., Milwaukee, Wis. This new rheostat,



NEW DIRECT-CURRENT REGULATING RHEOSTAT

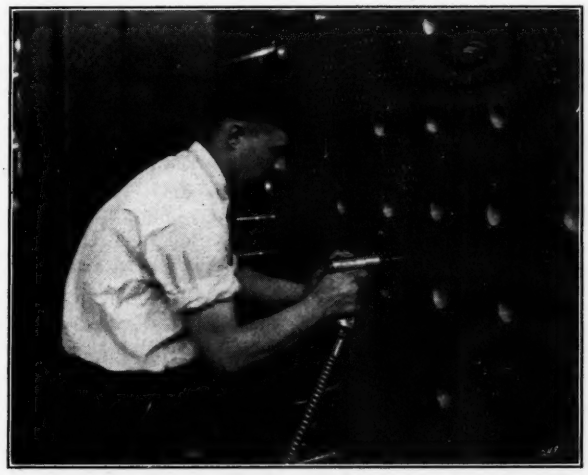
shown herewith, is designed to control the speed of fractional horsepower motors driving small blowers, fans, buffers, bookkeeping machines and similar apparatus; it can be used as a dimmer on lighting circuits, or it can be used as an electric heater regulator. The device is of the circular plate type, completely enclosed. It is small in size to permit mounting directly on machines or in any out-of-the-way place. The standard rheostat is furnished for conduit wiring but if open wiring is to be used, a porcelain bushing is quickly added. The mechanism consists essentially of a cement imbedded resistance unit, with brass contact buttons

protruding through the cement and a contact arm which moves over the buttons, varying the resistance. A small, neat-appearing enclosing case with an outside operating lever protects the unit and prevents accidental contact with live parts.

Jiffy Gun for Shooting Condenser Plugs

CONDENSER TUBES are often cleaned nowadays by shooting plugs of various materials through them. For shooting such plugs, the Jiffy Gun, shown here, has recently been placed on the market.

It is made of aluminum and is designed for operation by compressed air or water at a pressure as low as 50 lb. The tapered nozzle makes it adaptable for



JIFFY GUN SHOOTS PLUG WHEN NOZZLE IS PRESSED INTO TUBE END

tubes from ½-in. to 1-in. outside diameter, while for other sizes a special nozzle is furnished.

The nozzle of the gun is attached directly to a piston which is held by a spring so that it shuts off the air or water supply. When the gun is used, the nozzle is pressed into the end of a tube and the pressure on the nozzle pushes back the piston, allowing the air or water pressure to force the plug through the tube. Operation is intended to be entirely automatic, as there are no valves to be manipulated. The Jiffy Gun is a recent product of Liberty Mfg. Co., Jeannette, Pa.

HARVARD ADVERTISING Awards Committee of the National Industrial Advertisers Association announces the annual Bok Award of $2000 for the best industrial advertising campaign of 1928, appearing in newspapers and periodicals. Competition closes Dec. 31, 1928. Details of the form for submitting description of the campaign, market analysis on which it was based and reproductions of ads can be had from Harvard Graduate School of Business, Soldiers Field Station, Boston, or from A. H. Oberndorfer, Sivyer Steel Casting Co., Milwaukee, Wis.

ALL HONEST men will bear watching. It is the rascals who cannot stand it.

New Fisher Building One of World's Largest

RANKING AS ONE of the world's largest buildings, the first section of the new Fisher Building in Detroit is being completed by the New Center Development Corporation. This building, which will include shops, a general office and medical wing, an 11-story garage and a 3000-seat theater, will eventually occupy a square block and be seven times as large as its present capacity.

Although both electric power and steam will be purchased the method of handling and distributing electric

VIEW OF THE NEW FISHER BUILDING IN DETROIT LOOKING NORTHWEST FROM THE GENERAL MOTORS BUILDING

power, heating and ventilating design, service outlet floor construction and other features through the building are unusual and will be treated in detail, when the building is completed.

News Notes

ATLAS CONVEYOR Co., Inc., of 20 S. 15th St., Philadelphia, Pa., announces that A. J. Forschner, who joined the company in July as vice-president, has also taken over the duties of secretary for the company. E. A. Thumlert, formerly employed in this capacity, is no longer connected with the company and has not been since August 6, 1928.

RAYMOND WILCOX, formerly steam power engineer in the Department of Engineering Design of the Southern California Edison Co., has been made mechanical engineer of the steam generation department of that

company. In this new capacity, he will report to Frank G. Philo, superintendent of steam generation and will be located at the Long Beach steam plant.

FIFTIETH ANNIVERSARY of the Buffalo Forge Co. was celebrated at the annual three-day sales convention of the Buffalo Forge Co., Buffalo Steam Pump Co., and the Canadian Blower & Forge Co., Ltd., recently held at Buffalo, N. Y. Representatives of over 40 branch offices of these associated companies, ranging from Seattle to Atlanta and Los Angeles to Boston, took active part. The Canadian plants were represented with salesmen from Kitchener, Toronto, Winnipeg, Montreal and Vancouver. Both the South American and Porto Rican offices had one representative. The first day was spent in renewing acquaintances, discussing past meetings and visiting the factory. Jack De Visser, Detroit office, was the winner of the Golf tournament that took place the second day and was presented with a beautiful silver trophy. The driving contest was won by E. E. Johnson of the Buffalo office. On the third and last day, two business sessions were held.

ROBERT V. PRATHER, secretary of the Great Lakes Division of the National Electric Light Association, died suddenly Sunday morning, October 7, in St. Louis from a cerebral hemorrhage. Besides his N. E. L. A. connection, he was also secretary and treasurer of the Illinois State Electric Association, Illinois Gas Association and Illinois Electric Railways Association.

Born January 28, 1884, in Claremont, Ill., Mr. Prather spent most of his life in the electric light and power industry in the middle west. In 1914, he was appointed secretary of the Illinois Public Utilities Association by Governor Dunn and since that time made his home in Springfield. Resigning from the Public Utilities Commission in 1918, Mr. Prather devoted his energies to combining the three associations representing the gas, electric and railway industries. He was made secretary of all three associations.

WALTER G. HILDORF was recently placed in charge of all metallurgical work for The Timken Steel and Tube Co., Canton, Ohio. For the past several years, Mr. Hildorf has been metallurgical engineer for the Reo Motor Car Co., Lansing, Mich.

OLD FORGE ELECTRIC CORP., Old Forge, N. Y., has made application to the Public Service Commission for permission to take over the municipal electric lighting plant at that place, as well as lines and other facilities at Webb, an adjoining community, now receiving service from the Old Forge station. The application states that as soon as permission has been received, an expansion and improvement program will be carried out, including additions to existing plant and installation of new equipment.

COMPLETING the extensive transmission line project in the southern part of the San Joaquin Power system, the 50-mi. line from Corcoran to Midway Steam Plant has been switched on to the San Joaquin Light and Power Co.'s lines. Approximately 90 mi. of new 110,000-v. transmission line, together with important substation improvements, have been added to the power facilities of this rapidly growing territory during the past few months, representing an investment of almost $1,000,000. This line from Corcoran to Midway ties in with the line from Taft to Midway, completed the middle of July, making a 72-mi. direct line reënforcing the main transmission system from Corcoran to Taft, a line costing more than $450,000. Several substantial improvements in substation facilities have been made in connection with this new line, including the construction of a new substation at Taft costing $100,000 and additions at Midway steam plant and Corcoran substation. Completing the loop of main transmission lines in the South, joining Bakersfield and Midway steam plants, the 110,000-v. steel tower line from Rio Bravo substation to Bakersfield was completed last spring. This line cost about $132,000 and necessitated substation and steam additions involving an additional $300,000. New oil switches and other equipment were installed at Kern Oil substation and facilities added at Rio Bravo Substation and both steam plants to take care of the increased capacities.

PRELIMINARY PROGRAM for the second international conference on bituminous coal, to be held under the auspices of the Carnegie Institute of Technology in Pittsburgh from November 19 to 24, 1928, is announced by President Thomas S. Baker, chairman of the conference.

According to the program, more than 100 speakers, representing 12 nations, will take part. In addition, several other countries will be represented, it is expected, by either official delegates or visitors.

Sessions of the conference will be held in Carnegie Music Hall and in various halls of the Carnegie Institute of Technology. Afternoons will be devoted chiefly to sectional meetings of which there will be as many as five going on simultaneously. Evening features during the week will include a dinner given in honor of the speakers by President Baker on Monday night; a public meeting to hear addresses by Dr. E. E. Slosson, director of Science Service and Dr. E. W. Smith, of England, on Tuesday night; a smoker on Wednesday night; a banquet for the public on Thursday night, and a public meeting on Friday night to hear an address by Georges Claude, the eminent French scientist and inventor.

Trips to Pittsburgh District industrial plants and the Carnegie-New York University football game saturday afternoon, November 24, are also listed as entertainment features.

Books and Catalogs

"FINDING AND Stopping Waste in Modern Boiler Rooms," by Geo. H. Gibson, 804 pages, 5 by 7-in. flexible cloth binding, price $3. Published by the Cochrane Corp., Philadelphia, Pa.

This reference book, which is the third edition to be published, contains text, tables and charts compiled from papers read before engineering societies, books, articles in technical periodicals, publications of the U. S. Bureau of Mines and other original sources. This material is put into convenient form for various owners, managers, engineers, firemen and others interested in increasing and maintaining boiler plant economy. The book is divided into five sections dealing with fuels, combustion, heat absorption, boiler efficiency and testing. It also treats with water heating and conditioning. In this book the author aims to present data and methods by means of which a man can use and evaluate fuels, select the type of equipment best adapted for burning

them, operate such equipment at the highest efficiency and secure efficient transfer of heat thus developed to the steam. Recent practices in heat balancing are discussed as are also water conditioning and protection of the boiler and auxiliary equipment from scaling, embrittlement and corrosion.

"QUALITY CONCRETE in Every Type of Structure" is the title of bulletin No. 340, just issued by the Celite Products Co., 1320 S. Hope St., Los Angeles, Calif. This bulletin is well illustrated to show the application of concrete to many types of construction. including foundations, piers, sea walls, city buildings, storage silos and decorative work on churches.

"JONES TRUE BLUE PULLEYS" is the title of catalog No. 37 recently issued by W. A. Jones Foundry & Machine Co., 4401 W. Roosevelt Rd., Chicago, Ill. This catalog gives illustrations and general information relative to semi-steel pulleys and contains tables of dimensions.

DUPLEX POWER-DRIVEN AIR COMPRESSORS, straight-line steam and power-driven air and gas compressors, semi-Diesel oil engines, vertical duplex compressors, portable motor-driven compressors and vertical simplex air compressors are described in detail in a series of well-illustrated bulletins just issued by Chicago Pneumatic Tool Co., 6 East 44th St., New York. The numbers of these bulletins, in the order named above, are: 700, 720, 773, 786, 787 and 788.

LONG DISTANCE transmitting and recording systems for measuring temperature, liquid level, pressure and other quantities, for centralized control of operations, are described and illustrated in Bulletin 1900 just issued by The Bristol Co., Waterbury, Conn. Details of the equipment and connections are presented, with many interesting photographs of its applications.

"VALVES AND Gage Cocks" is the subject of Catalog No. 77, issued by W. C. West Co., 435 North Michigan Ave., Chicago, Ill.

The booklet gives specifications and construction for globe, angle and check valves in brass and iron construction of all types, with a complete list of sizes, parts and list prices.

AMONG RECENT publications of the Westinghouse Electric and Manufacturing Co. is leaflet 20,383, descriptive of the adjustable insert, designed to facilitate mounting machinery or other equipment to floors, walls or ceilings of concrete. The insert has a cast-iron housing which may be set in concrete. A rotatable bolt carrier of high grade malleable iron, T-slotted to take the head of a standard square head machine bolt is held in the housing by a retaining spring and steel plug pressed in at the back. The housing and bolt carrier both are provided with teeth which mesh and prevent any change in position after the adjustment has been made and before the bolt is tightened. The inserts are available for use with ⅜ and ½-in. machine bolts.

IN A TREATISE on corrosion of lead cable sheaths, entitled Twentieth Century Mythology, Murray Conduit System of 55 Duane St., New York City, classifies the causes of corrosion, electrolysis, oxygen, stress, moisture, chemical composition, difference in air contact; also the preventives of corrosion, carbon dioxide, sodium carbonate, lead carbonate, which help form obstructive films. Conclusion is reached that moisture is the most important factor in corrosion both as to electrolytic effect and as a carrier of corrosives in solution, so that, if ducts are kept dry, no corrosion to speak of will take place. Concrete duct 28 days old is stated to be safe but all ducts should have good drainage between manholes.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for October 1, 1928.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering and that the following is, to be best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
W. A. Phillis, Cleveland, O.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

CHAS. SANFORD CLARKE, Sec'y.

Sworn to and subscribed before me this 28th day of September, 1928.

Eddie H. Kahl.

(My commission expires March 20, 1932.)

NOTE.—This statement must be made in duplicate both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Power Plant Construction News

Ala., Talladega—The Bemis Brothers Bag Co., 601 South Fourth Street, St. Louis, Mo., is asking bids on general contract for new plant at Talladega, including one-story boiler house, 49 x 50 ft., and other mechanical units. Entire project will cost more than $2,000,000. J. E. Sirrine & Co., Greenville, S. C., are engineers.

Ark., Waldo—The Common Council plans the installation of pumping machinery and auxiliary equipment in connection with a new municipal waterworks and sewage system to cost about $80,000. E. T. Archer & Co., New England Building, Kansas City, Mo., are engineers.

Calif., Los Angeles—The Los Angeles Chemical Co., 2200 Santa Fe Avenue, plans installation of power equipment in proposed new plant on 7-acre tract of land at South Gate, entire project reported to cost more than $150,000.

Calif., Stockton—The National Paper Products Co., Church Street, plans installation of power equipment in proposed new mill addition to cost close to $100,000.

Colo., Alamosa—The Public Service Co. of Colorado, Denver, has authorized construction of a new steam-operated electric power plant at Alamosa, and extensions and improvements in transmission lines and substation facilities in that district, for which an appropriation of $125,000 has been arranged.

Conn., Fairfield—The McKesson & Robbins Co. plans installation of power equipment in new five-story addition to local drug and chemical plant to cost more than $175,000. Fletcher-Thompson, Inc., Bridgeport, Conn., is architect and engineer.

Ill., Chicago—The Peoples Gas Light & Coke Co., 122 South Michigan Avenue, has filed plans for a two-story compressor plant at Lawndale Avenue and Seventy-third Street, estimated to cost about $70,000 with equipment.

Ill., Chicago—The Illinois Steel Co., South Chicago, has filed plans for a one-story power substation at its steel works to cost about $70,000, with equipment.

Ill., Rockford—The Eastwing Mfg. Co., 2031 Ninth Street, manufacturer of tools, plans installation of power equipment in proposed rebuilding of portion of plant recently destroyed by a tornado, reported to cost more than $60,000.

Ill., Rock Island—The International Harvester Co., 606 South Michigan Avenue, Chicago, plans installation of power equipment in proposed new plant units at Rock Island, entire project to cost more than $400,000. W. D. Price is superintendent of construction for the company.

Ky., Somerset—The R. J. Smith Co., Somerset, is planning early construction of new electric-operated cold storage plant reported to cost in excess of $50,000, with equipment.

La., Oakdale—The Louisiana Public Utilities Co., Lafayette, La., plans the rebuilding of portion of generating station at Oakdale, destroyed by fire, Oct. 1, with loss reported in excess of $100,000, including equipment.

Md., Amcelle—The Celanese Corporation of America, Amcelle, near Cumberland, is completing plans for construction of one-story turbine plant at its local rayon mill, to cost about $150,000. F. T. Small is company engineer.

Mass., Hudson—The Municipal Light and Power Department is planning extensions and improvements in municipal power station on Cherry Street, including the installation of additional equipment. L. D. Wood is manager.

Mass., Woronoco—The Strathmore Paper Co., Mittineague, Mass., plans installation of power equipment in connection with a new four-story addition to its mills at Woronoco, entire project to cost more than $150,000.

Mich., Detroit—The C. H. McAleer Mfg. Co., 4718 Burlingame Street, plans installation of power equipment in proposed new addition to polishing product manufacturing plant, entire project reported to cost more than $100,000.

Mich., Detroit—The Motor Wheel Corporation, General Motors Building, plans installation of power equipment in two new units at local plant, entire project reported to cost more than $100,000.

Mo., Kansas City—The Sheffield Steel Corporation, 7500 Independence Road, will proceed with the construction of a one-story power plant at its mill, reported to cost close to $40,000, with equipment.

Neb., Cozad—The Peoples Sugar Co., Moroni, Utah, is said to be planning construction of a power house in connection with proposed beet sugar mill at Cozad, entire project to cost close to $500,000. N. G. Stringham is vice-president.

N. J., Jersey City—The Public Service Electric & Gas Co., Newark, is completing plans for a two-story equipment storage and distributing plant on New York Avenue, 140 x 180 ft., reported to cost more than $200,000, with equipment.

N. Y., Brooklyn—I. Rokeach & Sons, 345 Hewes Street, manufacturers of soaps, plans installation of electric power equipment in a new four-story plant unit on Wythe Avenue to cost more than $100,000, for which a building permit has been issued.

N. Y., New York—The Manhattan Refrigerating Co., 521 West Street, has plans under way for a new addition to plant to cost close to $100,000, with equipment.

N. C., Albemarle—The Wiscasset Mills Co. plans installation of power equipment in proposed new addition to hosiery mills, entire project reported to cost close to $450,000.

Ohio, Akron—The General Tire & Rubber Co. plans installation of power equipment in connection with a projected expansion program to increase capacity about 50 per cent, reported to cost more than $1,000,000.

Ohio, Cleveland—The Precision Die Casting Co., Fayetteville, Syracuse, N. Y., plans installation of power equipment in a proposed new plant at Cleveland, entire project to cost close to $100,000.

Ohio, Toledo—The Citizens Necessities Co., Toledo, George C. Shepard, vice-president and general manager, is said to be planning the construction of two new ice-manufacturing plants to cost upward of $350,000, with machinery.

Okla., Sand Springs—The Tulsa Rolling Mill Co. will install power equipment in three new plant units, entire project to cost more than $100,000.

Pa., Philadelphia—The Gulf Refining Co., Girard Point, has filed plans for the construction of a one-story boiler plant on Penrose Ferry Road, near the Schuylkill River, to cost close to $35,000.

Pa., Reading—The Carpenter Steel Co. plans installation of electric power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, Oct. 6, with loss reported in excess of $500,000.

Pa., Vandergrift—The American Sheet & Tin Plate Co., Frick Building, Pittsburgh, Pa., plans installation of power equipment in connection with expansion and improvement program at Vandergrift mills to cost more than $1,500,000.

R. I., Cranston—The City Council plans the installation of a group of six or seven pumping plants in connection with expansion and improvements in municipal sewage system, entire project will cost about $2,500,000. Fay, Spofford & Thorndike, 44 School Street, Boston, are consulting engineers.

Tenn., Cleveland—The Cleveland-Tennessee Enamel Co., care of W. B. Evans, Sterling Court, Nashville, Tenn., recently organized, is said to be planning the construction of a boiler plant in connection with new enameling and stamping mill at Cleveland, entire project to cost approximately $100,000.

Texas, Weatherford—The Weatherford-Mineral Springs & Northwestern Railway Co., plans installation of power equipment in connection with proposed rebuilding of local engine house, machine and tool shop, recently destroyed by fire with loss reported at close to $100,000.

Wash., Seattle—The Rhinelander Paper Co., Rhinelander, Wis., is reported planning construction of a power house in connection with a projected pulp and paper mill in the vicinity of Seattle, including pumping station and other mechanical departments. Entire project is reported to cost more than $1,500,000. William E. Eibel is general manager.

Wis., Milwaukee—The Sperry Candy Co., 140 Reed Street, will install power equipment in a one-story and basement factory to be erected on Pittsburgh Avenue, entire project to cost about $100,000. C. W. Tharinger and John P. Bruecker, 774 Third Street, are architects and engineers.

Wis., Racine—The Bell City Malleable Iron Co., Kewaunee Street, has filed plans for a two-story power plant, 50 x 80 ft., reported to cost more than $60,000, with equipment. A. A. Wickland & Co., 205 West Wacker Drive, Chicago, Ill., are engineers.